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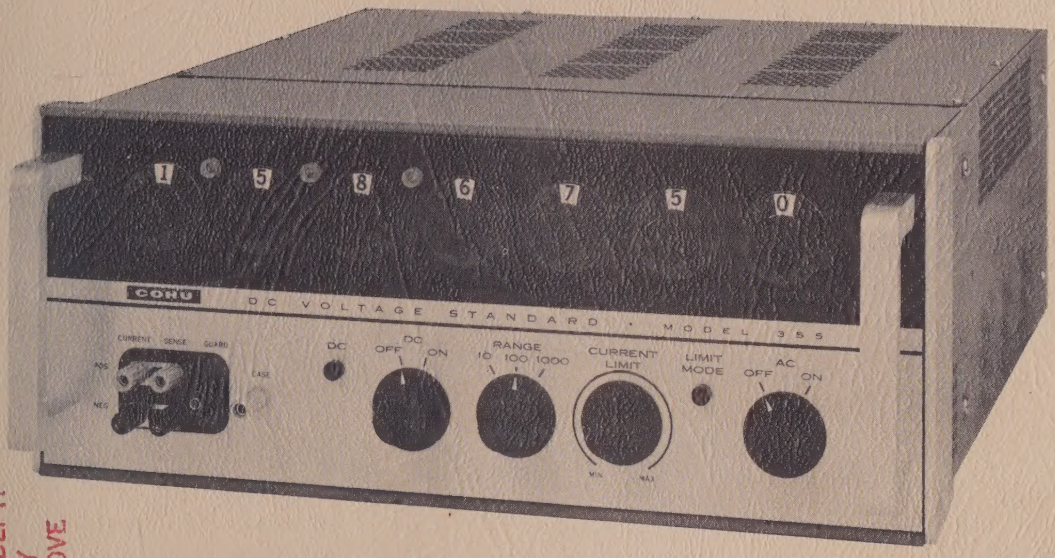

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OPERATING AND MAINTENANCE INSTRUCTIONS FOR

DC VOLTAGE STANDARD

MODEL 355

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COHU
ELECTRONICS, INC
SAN DIEGO DIVISION

Technical Manual
Code No. 15X-78

OPERATING AND MAINTENANCE INSTRUCTIONS FOR MODEL 355 DC VOLTAGE STANDARD

SERIAL NUMBERS 1-0001 AND HIGHER

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COHU ELECTRONICS, INC.
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Section I
GENERAL DESCRIPTION

1-1. INTRODUCTION

The Model 355 DC Voltage Standard provides voltage from 0.000000 volt to 1111.1110 volts. The instrument is capable of furnishing current to 50 milliamperes at all voltage settings. The desired output voltage is obtained by selecting the appropriate voltage range and setting seven 11-position decade dials. The selected voltage is indicated by the decade dials, which provide an in-line readout with illuminated decimal-point placement.

The output current can be limited to a level determined by the setting of a front panel control. When the current is being limited a front panel indicator lights. The output voltage can be reduced to zero by a front panel switch. When the output terminals are energized a front panel indicator lights. The instrument is protected from overvoltage by circuitry that automatically limits the output voltage.

The Model 355 is shown in Figure 1-1. It is designed for bench use, but may be secured in a standard, 19-inch rack using the two mounting adapters that are supplied with the instrument. All operating controls, indicators, and output terminals are on the front panel. The output terminals are duplicated at the rear if so specified when the instrument is ordered. The ac-power entry and fuse are located at the rear. The instrument is a solid-state device and most of the circuits are on etched-circuit boards, the majority of which are of the plug-in type. The circuits are shielded by an internal enclosure in addition to the outer enclosure.

1-2. GENERAL DESCRIPTION

Figure 1-2 is a basic block diagram of the instrument. Setting the range and decade dials for the desired output voltage selects a reference current and precision decaded-feedback resistors. The current flows

Figure 1-1. Model 355 DC Voltage Standard

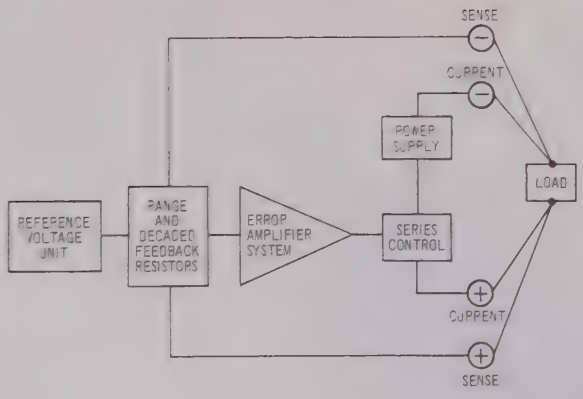

Figure 1-2. Basic Block Diagram

through the selected resistors producing a voltage that is compared with the voltage sensed across the load. Any difference between the set and sensed voltages is applied to the error amplifier system, which drives the series control. Current from the power supply passes through the series control and the load. The amplifier system drives the series control such that the voltage across the load equals the voltage setting.

1-3. SPECIFICATIONS

Specifications of the instrument are listed in Table 1-1.

For a period of 30 days after calibration the output voltage, referred to the volt maintained by the National Bureau of Standards, is equal to the set value within the tolerances specified in Table 1-1 (>3σ values). The accuracy specification includes the effects of stability and any combination of variables within the limits of the standard reference conditions stated below:

Constant external load

Ambient temperature, 23° ±1°C

Relative humidity, ≤55 percent

Atmospheric pressure, 575 to 800 millimeters of mercury

AC-line voltage, nominal ±1 volt rms

AC-line frequency, nominal ±0.5 hertz

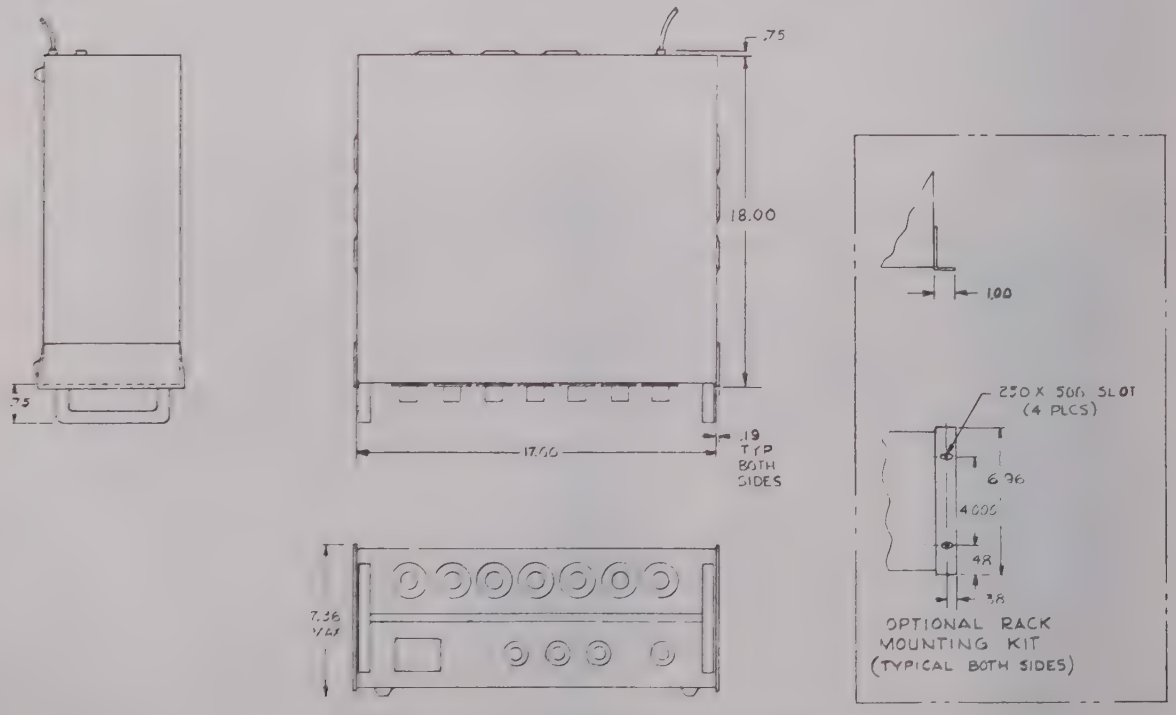

Figure 1-3. Dimensions and Outline

Table 1-1. Specifications

VOLTAGE RANGES AND RESOLUTION:	10V range 0.000000 to 11.111110 (1-μV steps) 100V range 00.00000 to 111.11110 (10-μV steps) 1 KV range 000.0000 to 1111.1110 (100-μV steps)
OUTPUT VOLTAGE ACCURACY: (Refer to para. 1-3 and plot on page 1-4)	10V range ±(0.001% of setting +5 μV) 100V range ±(0.001% of setting +20 μV) 1 KV range ±(0.001% of setting +40 μV)
OUTPUT CURRENT CAPABILITY:	To 50 milliamperes at any voltage setting (Current can be limited within the range of approximately 1 to 50 mA by a front panel control.)
NOISE AND HUM:	10V range <15 μV rms 100V range <20 μV rms 1 KV range <30 μV rms
COMMON-MODE REJECTION:	Better than 140 dB from dc to 400 Hz (Output voltage changes $<10^{-7}$ of the applied common-mode voltage.) Maximum common-mode voltage is 700 volts rms or 1000 volts dc
SOURCE RESISTANCE:	<(0.0005 or 0.0001 E_o) ohm at dc
SETTLING TIME:	Output voltage settles to within 0.001% of final output in less than 10 seconds
LOAD REGULATION:	<(0.0005% of setting or 25 μV) no load to full load
LINE REGULATION:	<(0.0005% of setting or 25 μV) for a 10% change from nominal ac-power line voltage
TEMPERATURE COEFFICIENT:	<(0.0002% of setting +1 μV)/°C
TEMPERATURE AND HUMIDITY:	Performance specifications apply for operating temperatures from +20° to +40°C with humidity to 70%
POWER REQUIREMENTS:	115/230V nominal ±10%, 50-60 Hz, single phase, approximately 130 VA
STORAGE TEMPERATURES:	From -40° to +65°C
DIMENSIONS:	See Figure 1-3
WEIGHTS:	Net, 53 pounds; shipping, 65 pounds

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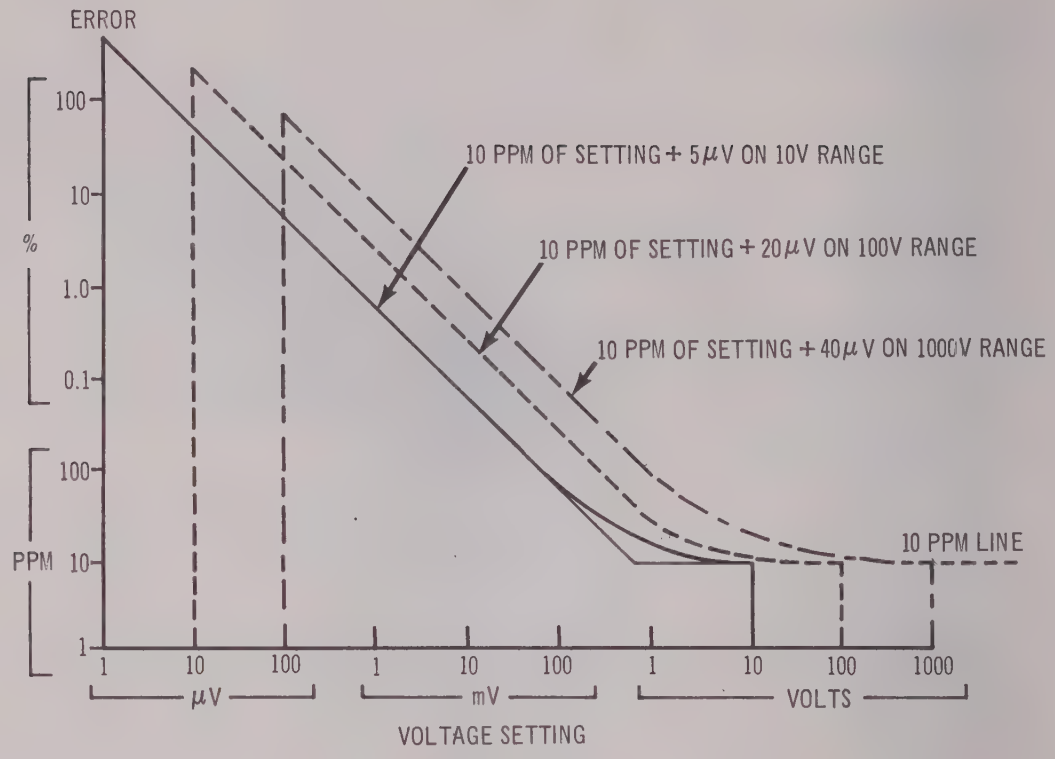

ERROR VERSUS VOLTAGE SETTING

Section II
INSTALLATION AND OPERATION

2-1. RECEIVING INSPECTION

Immediately upon receipt of equipment, inspection should be made to reveal any visible or functional damage which may have occurred in shipment. (See Form P-293-5-62-5M enclosed in the packing container.) Operational testing must be performed to ascertain whether concealed damage has been incurred in transit.

2-2. WARRANTY

Standard warranty certificate, Form No. S-212 (on the inside back cover), applies to this equipment. Instructions and conditions stated or implied in this manual are not to be interpreted in any manner which would conflict with or modify the meaning or intent of the warranty.

2-3. INSTALLATION

The instrument may be used as a bench unit or mounted in a standard, 19-inch rack. To prepare the instrument for rack-mounting, replace the plate at each side with a mounting adapter using the two screws from the removed plate and two screws supplied with the adapter, and remove the four rubber feet. The instrument may then be secured in a rack by means of the mounting adapters and four screws (not supplied). To allow for ventilation the cutouts and louvers in the case should not be obstructed, and the ambient temperature should not exceed +40°C.

2-4. AC-POWER CONNECTION

The instrument is designed to operate from a 115-volt or 230-volt, single-phase, 50 to 60 hertz source, and is connected for 115-volt operation unless 230-volt operation is specified. The instrument has a three-pin, ac-power-line plug, which should be connected to the source so that the case of the instrument is grounded.

2-5. TERMINAL CONNECTIONS

The instrument has six terminals on the front panel which will accept spade lugs and banana plugs. Two terminals furnish current, and two terminals permit the voltage across the load to be sensed. The terminal designated GUARD may be connected to the low side of the load or driven by external circuitry to increase the effective common-mode impedance. The terminal designated CASE may be used to ground the load. The terminals can be connected to provide two-terminal or four-terminal outputs, which may be applied to isolated or grounded loads.

2-6. TWO-TERMINAL OUTPUT. Two-terminal output may be used when the load is near the instrument or for high-resistance loads. For two-terminal positive output, connect the load to the terminals as shown in Figure 2-1; for a negative output, connect the load as shown in Figure 2-2. Omit the ground connection if a load is already grounded or is to remain isolated.

2-7. FOUR-TERMINAL OUTPUT. Four-terminal output should be used when the load is located some distance from the instrument or for low-resistance loads. The voltage at the load is one part per million of full scale higher than the set value for

each ohm of the total loop resistance of the sensing leads. For four-terminal positive output, connect the load as shown in Figure 2-3; for a negative output, connect the load as shown in Figure 2-4. If an isolated load is to be grounded using the CASE terminal on the front panel, the terminal should be connected by a separate lead to the low side of the load. If a load is to remain isolated or is already grounded, omit the ground connection from the CASE terminal.

2-8. SERIES-CONNECTED INSTRUMENTS. Voltages up to twice the maximum output voltage of one instrument can be obtained by connecting two instruments as shown in Figures 2-5 and 2-6. Voltage between the positive terminals and GUARD terminal and voltage between GUARD terminal and ground will be limited to the maximum output voltage of one instrument.

2-9. REAR TERMINALS. If the instrument is equipped with terminals at the rear they should not be used simultaneously with the front-panel terminals. Connect the load to either the front-panel terminals or the rear terminals.

NOTE

Before making connections to either the front or rear terminals make sure that the other set of terminals is free of all connections.

2-10. OPERATION

The instrument's operating controls and their functions, the uses of the overrange positions of the decade dials, and a recommended operating procedure are given in the following paragraphs.

2-11. OPERATING CONTROLS

The operating controls and indicators and their functions are listed in Table 2-1. The locations of the controls and indicators are shown in Figure 2-7.

2-12. OPERATING PROCEDURE

The instrument has two modes of operation: voltage regulation and current limiting. The LIMIT MODE lamp indicates the mode of operation. The instrument is in the voltage-regulation mode when the lamp is not lighted and in the current-limiting mode when the lamp is lighted. Crossover from voltage regulation to current limiting occurs if the load attempts to draw more than a preselected level of output current. In the current-limiting mode, the output voltage, which is determined by a constant output current and the resistance of the load, will be less than the voltage indicated by the decade dials.

The crossover point is selected by the CURRENT LIMIT control. If current limiting is not important the control may be set to MAX. When it is desired to limit the output current to a level less than the maximum capability of the instrument, the control should be set appropriately. Alternate operating instructions for the two conditions are in step e of the following procedure:

a. Set DC switch to OFF.

b. Set AC switch to ON and allow approximately 30 minutes for instrument to stabilize.

c. Connect load to instrument.

d. Set RANGE and decade dials for required output voltage.

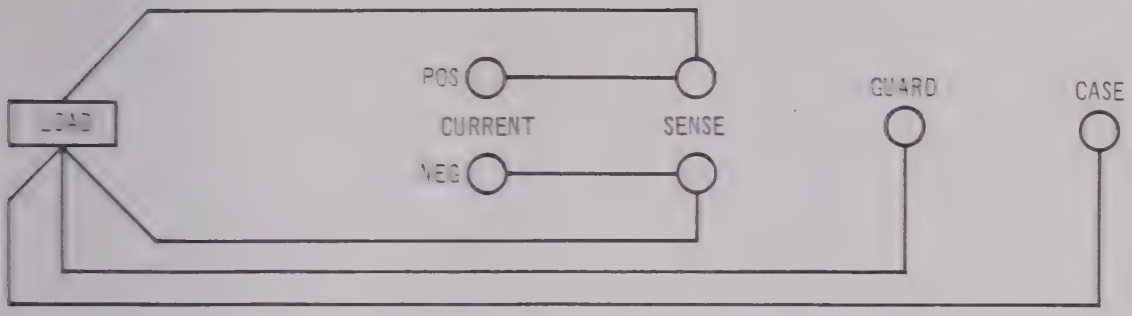

Figure 2-1. Two-Terminal Positive Output

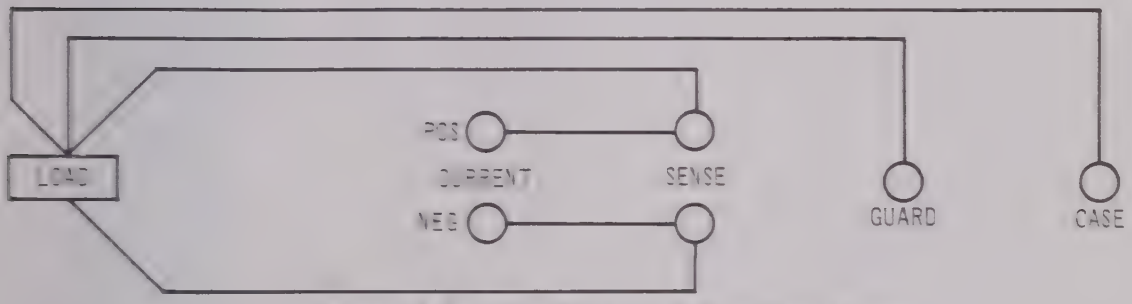

Figure 2-2. Two-Terminal Negative Output

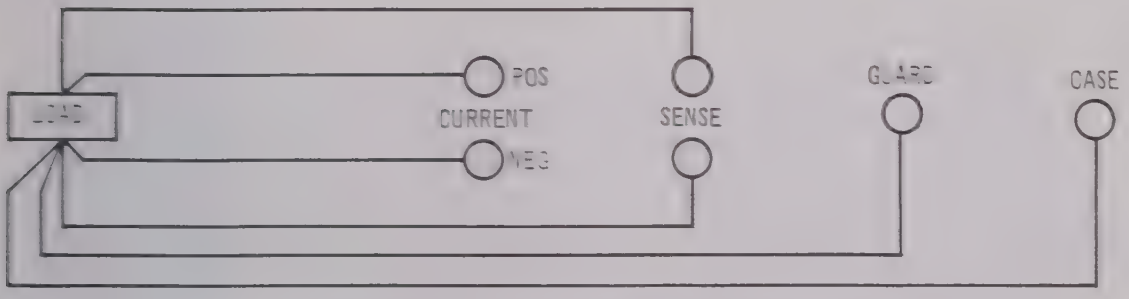

Figure 2-3. Four-Terminal Positive Output

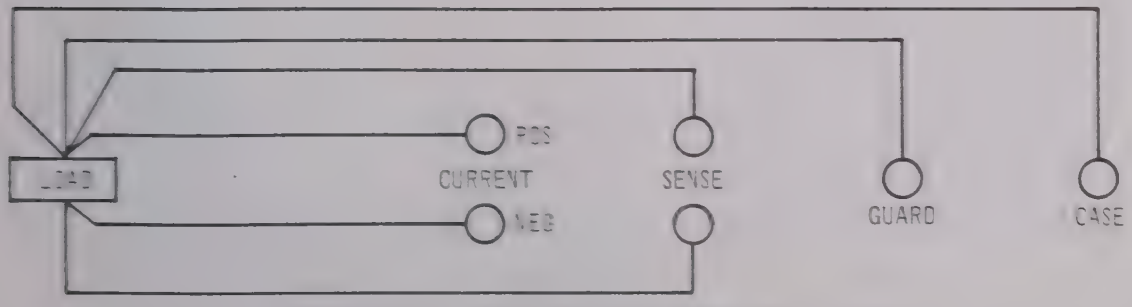

Figure 2-4. Four-Terminal Negative Output

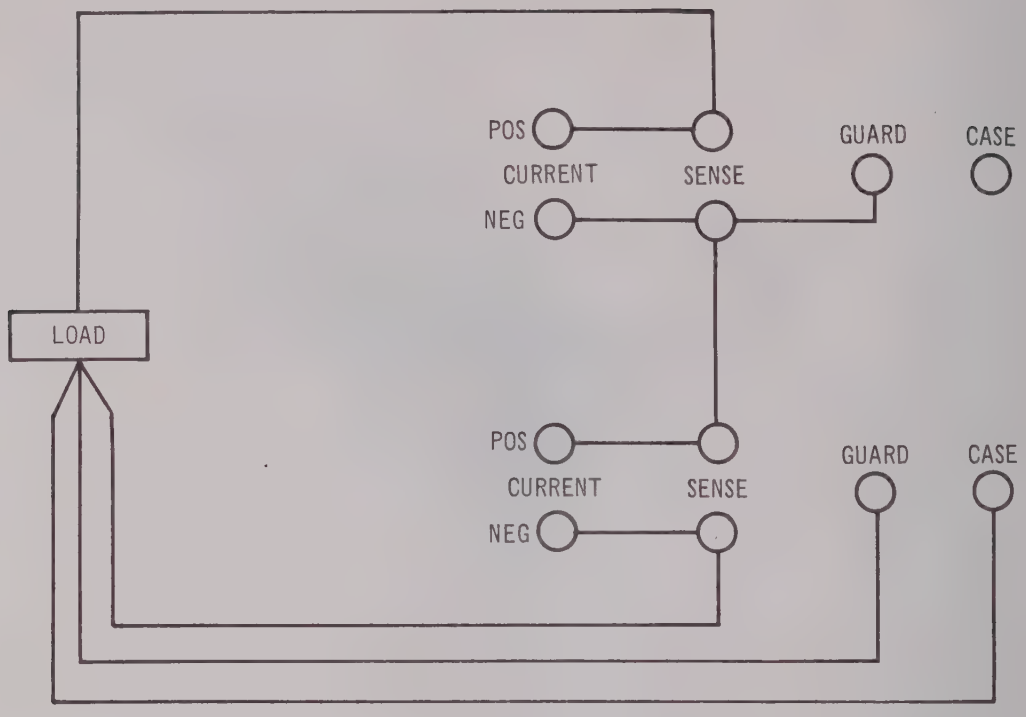

Figure 2-5. Two Instruments Connected for Positive Output

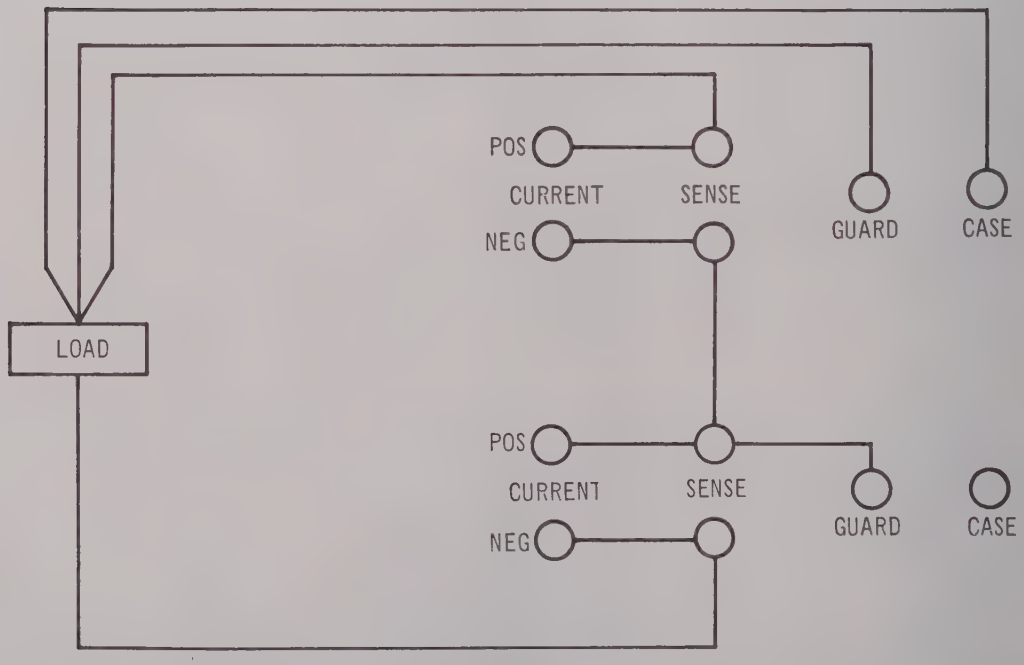

Figure 2-6. Two Instruments Connected for Negative Output

Table 2-1. Operating Controls and Indicators

Name	Circuit Ref.	Function
RANGE	S1	Selects nominal full-scale 10V, 100V, and 1000V ranges
Decade dials	S2 through S8	Set level of output voltage within range selected
AC	S9	Energizes instrument
DC	S10	Energizes output terminals
CURRENT LIMIT	R62	Limits output current to level selected
Decimal-point indicators	DS1, DS2, DS3	Indicate decimal-point placement according to voltage range selected
DC	DS4	Lights when output terminals are energized
LIMIT MODE	DS5	Lights when output current is being limited to value set by CURRENT LIMIT control

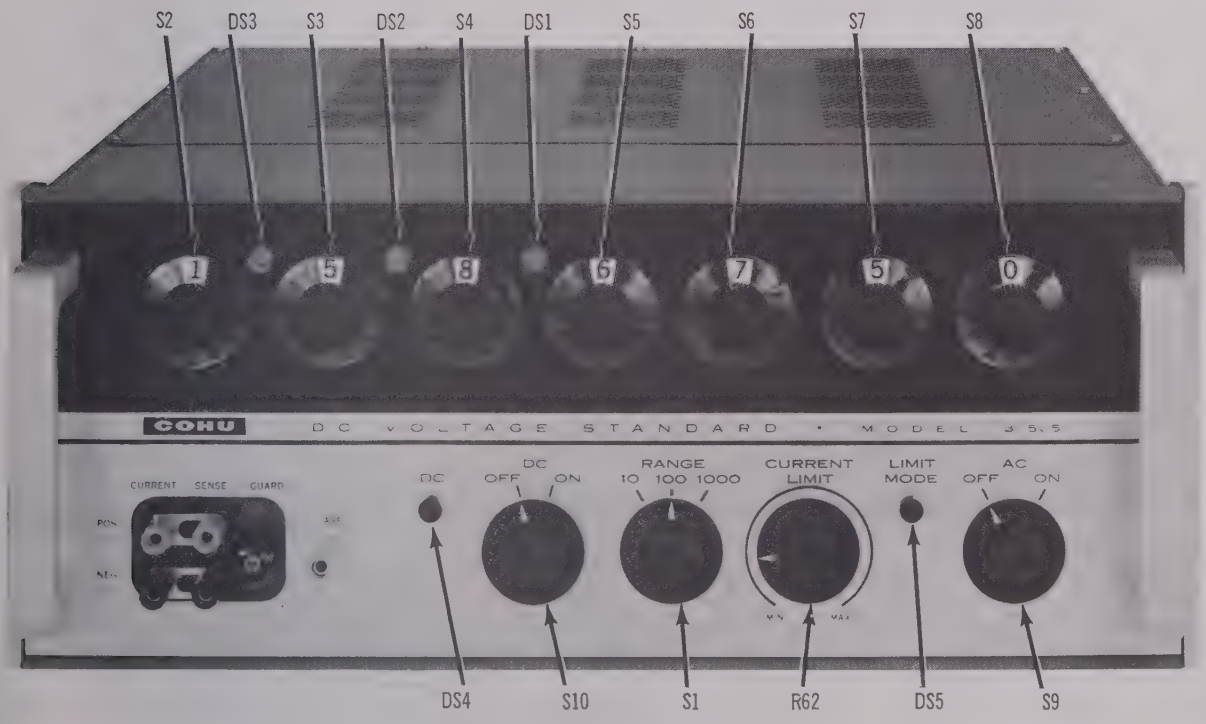

Figure 2-7. Locations of Operating Controls and Indicators

e. Set CURRENT LIMIT control to MAX and DC switch to ON,

OR

first set CURRENT LIMIT control to MIN, set DC switch to ON, and then turn control clockwise until LIMIT MODE lamp extinguishes.

NOTE

If the output voltage is subsequently set to a higher level, and thereby increasing the output current, the LIMIT MODE lamp may light. When this happens, advance the control until the lamp extinguishes.

2-13. OVERRANGE DIALING

Each of the decade dials has eleven positions. The dial at the extreme left has positions 0 through 9, and an overrange position marked 10. The other dials each have positions 0 through 9, and an overrange position marked X. The X position of a dial indicates a voltage ten times greater than that of position 1 of the same dial, and equal to the voltage indicated by position 1 of the next higher-decade dial (the dial to the left). By using the overrange positions, the same output voltage can be obtained with several different decade dial settings on each range; this permits the output voltage to be compared (using external indicating equipment) and provides a means for "self-checking" the linearity of the decade resistors. Also, it is sometimes more convenient to use the overrange positions to change the level of output voltage. Use of the overrange positions also occurs when voltages above the nominal full-range value are set. To illustrate these features of the instrument some examples are given in Table 2-2.

Table 2-2. Examples of Dial Settings Using Overrange Positions

Feature	Dial Setting	Output Voltage
Convenient to use the X position to change output voltage	199.9000	199.9
	199.X000	200
Linearity self-check (100-volt range)	49.9999X	50
	49.999X0	50
	49.99X00	50
	49.9X000	50
	49.X0000	50
	4X.00000	50
	50.00000	50
Necessary use of the X positions	10XX.XXXX	1111.1110

Section III
CIRCUIT DESCRIPTION

3-1. GENERAL CIRCUIT DESCRIPTION

The instrument is basically a low drift, wideband, high gain, negative feedback amplifier system. The feedback control is based on the network theorem that the algebraic sum of the currents at a junction equals zero. In Figure 3-1, E_{in} is the reference voltage, R1 is the selected range resistor, R2 represents the selected feedback-decade resistors, A is the gain of the amplifier system, and E_{out} is the output voltage of the instrument. If the input current of the amplifier is negligible, all the current in R1 must flow through R2. The equation for the output voltage is:

$$E_{out} = -\frac{R2}{R1}\left[\frac{A\ \frac{R1}{R1+R2}}{1+A\ \frac{R1}{R1+R2}}\right] E_{in}$$

If $A\frac{R1}{R1+R2} >> 1$ the term in the bracket is almost unity. Assuming that A is sufficiently large, the output voltage becomes simply $E_{out} = -\frac{R2}{R1} E_{in}$. The amplifier system has the required gain and the input characteristics necessary to make the assumptions involved in the approximate equation valid for output voltage from 0 to -1111.1111 volts. The output is isolated from the outer case and the ac-power lines so that output terminal inversion is possible to obtain output voltage from 0 to +1111.1111 volts.

A simplified block diagram indicating the functional sections of the instrument is shown in Figure 3-2. The major functional section is the error amplifier system. The characteristics of the amplifier system are such that the accuracy of the output voltage of the instrument is almost independent of all influences except the reference voltage and the ratio of the range resistors to the decaded-feedback resistors. The reference-voltage circuit provides a constant voltage for the range and feedback network. The feedback network consists of seven decades of precision resistors; the resistors are selected and connected in series when the decade switches are set for a desired output voltage. The range switch selects one of three sets of precision resistors, the selected resistors determining the current in the feedback network. The constant current in the feedback network develops a precision voltage across the selected resistors.

Any difference between the precision voltage developed across the selected decaded-feedback resistors and the output voltage of the instrument appears as an error voltage at the input of the amplifier system. The amplifier system consists of a 60-hertz, suppressed carrier modulator; a carrier amplifier demodulator; a wideband amplifier; a dc amplifier; and a driver amplifier. The dc and lower frequency components of the error signal at the amplifier system input are amplified by the carrier amplifier. The higher frequency components of

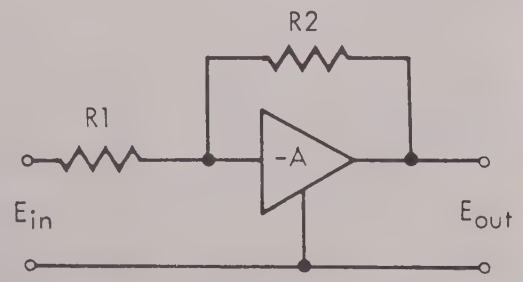

Figure 3-1. Feedback Amplifier

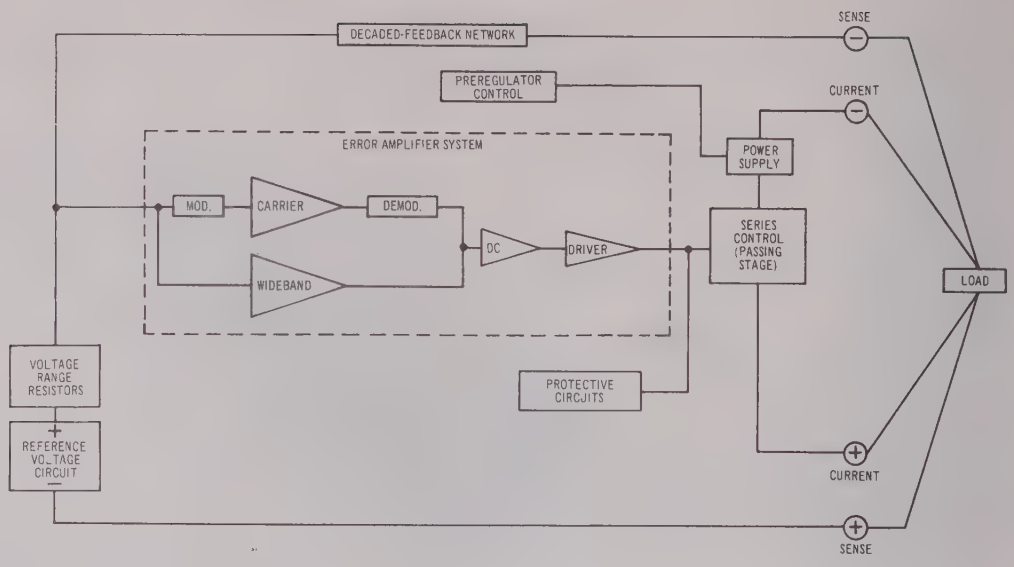

Figure 3-2. Functional Block Diagram

the error voltage are amplified by the wideband amplifier, which parallels the carrier amplifier. The carrier and wideband amplifier outputs are combined to provide a reconstituted error signal at the dc amplifier input. The dc amplifier output is applied to an amplifier that drives the passing stage to maintain the instrument output voltage equal to the precision voltage across the decaded-feedback network.

In addition to the main regulating loop, already described, the instrument contains secondary regulating loops, provided by the preregulator control and the protective circuit. The preregulator control maintains the voltage across the passing stage at a safe level by varying the output of the power supply according to the required output voltage of the instrument. The protective circuit provides overvoltage protection by limiting the overvoltage to a level that is a small percentage of the selected output voltage. The protective circuit also provides overcurrent protection by causing the instrument to change from its normal voltage-regulating mode to a constant-current mode of operation, the level of current being determined by the setting of the front panel CURRENT LIMIT control.

3-2. DETAILED CIRCUIT DESCRIPTION

In the following paragraphs of this section the circuits of the instrument are discussed in more detail with the aid of circuit and block diagrams.

3-3. POWER SUPPLIES AND DISTRIBUTION

Power is supplied via a single transformer, T1, that has two primary and eight second-

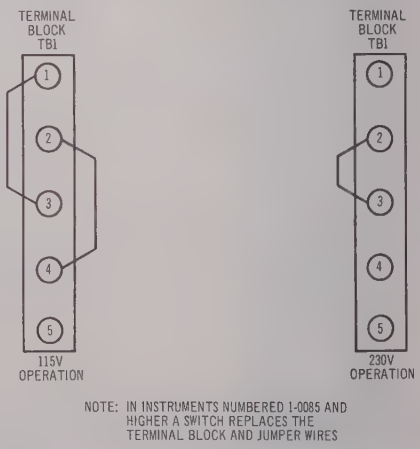

Figure 3-3. Power Transformer Primary Jumper Wire Connections

ary windings. As indicated in Figure 3-3 the primary windings can be connected for nominal 115-volt or 230-volt operation by jumper wires; instruments numbered 1-0085 and higher have a switch for this purpose. The transformer and power supplies distribute ac, unregulated dc, and regulated dc voltages as indicated in Figure 3-4.

3-4. AC-VOLTAGE DISTRIBUTION. The secondary windings of the power transformer provide the following voltages:

6.3 volts for chopper drive and demodulator

15 volts for reference-circuit heater

40 volts for reference-circuit-heater control

100 volts, 62 volts, and two 34-volt supplies for unregulated power supply board. One of the 34-volt supplies also goes to the preregulator control board.

115 volts for high-voltage board

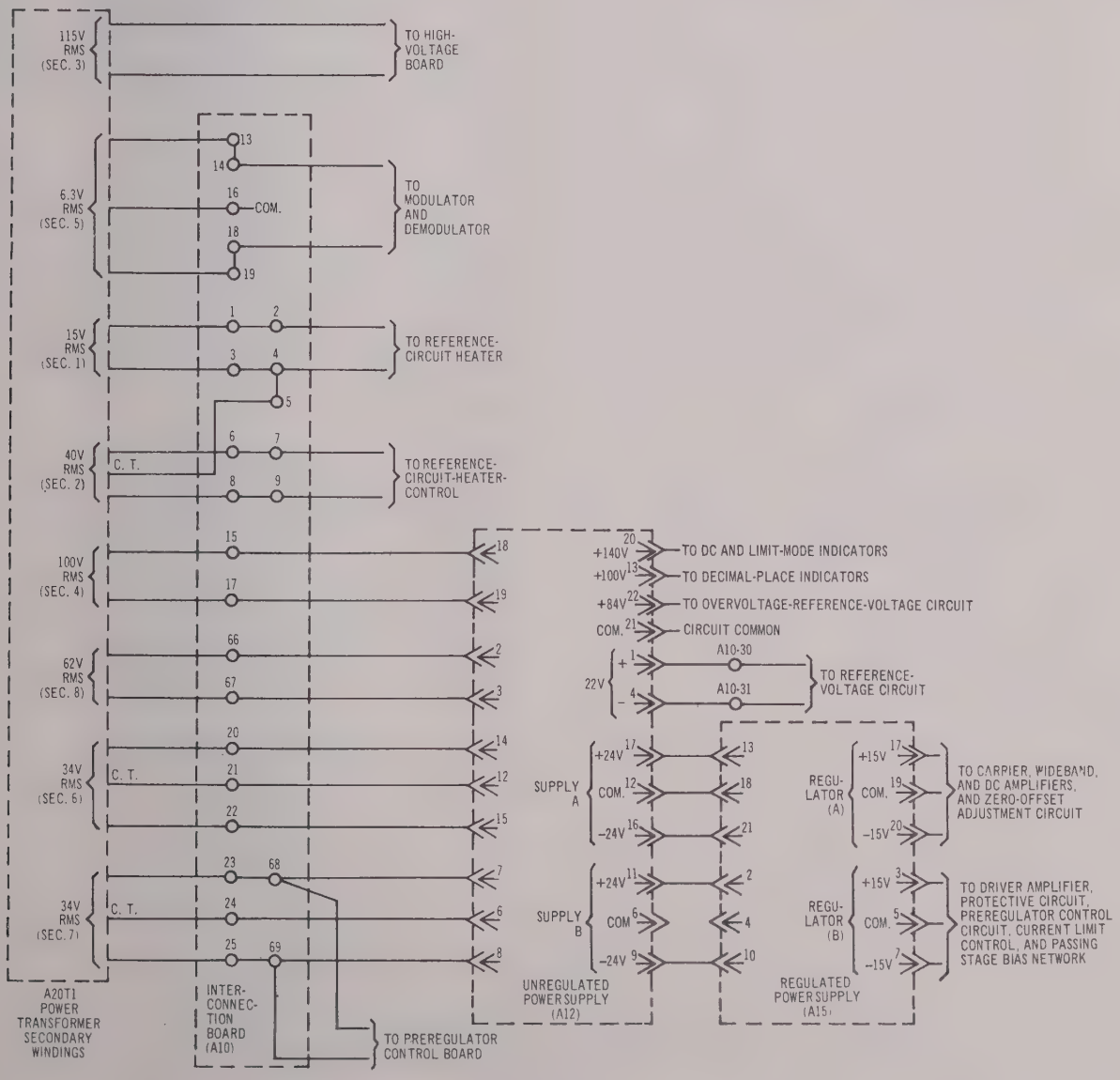

Figure 3-4. Power Distribution

3-5. UNREGULATED DC-VOLTAGE DISTRIBUTION. Unregulated dc voltages are provided by the unregulated power supply board, A12, which has four separate bridge rectifier and smoothing circuits. The unregulated power supply distributes the following voltages:

+140 volts for DC and LIMIT MODE indicators

+100 volts for decimal-place indicators

+84 volts (Zener regulated, adjustable) for overvoltage-reference-voltage circuit

22 volts (Zener regulated) for reference-voltage circuit

Two 24-volt supplies, designated A and B, for 15-volt power supply board

3-6. REGULATED DC VOLTAGE DISTRIBUTION. Regulated dc voltages are provided by the 15-volt regulated power supply board, A15, which distributes the following voltages:

+15 volts (A) and -15 volts (A) for carrier, wideband, and dc amplifiers and zero-offset adjustment circuit

+15 volts (B) and -15 volts (B) for driver amplifier, protective circuit, preregulator control circuit, current limit control, and biasing passing circuit A20Q3/A20Q4

3-7. 15-VOLT REGULATED POWER SUPPLY. The 15-volt regulated power supply board has two identical circuits, A and B. Each circuit provides regulated +15-volt and -15-volt outputs, and is comprised of two regulators that are identical except for the polarities of the transistors. Figure 3-5 shows the circuit of the regulator that provides the +15-volt A-supply. The reference voltage is established by Q11. A sampling of the output voltage, applied to the base of Q5, is compared with the reference voltage, applied to the emitter. The difference between the two voltages, the error voltage, is amplified by Q5 and Q1, the output of which is applied to a Darlington-connected passing stage, Q2/Q3. The amplified error voltage controls the current through the passing stage and, hence, the output voltage of the regulator. The output voltage is adjustable by means of R8.

Overcurrent protection is provided by the circuit that includes R5 and Q4. An overcurrent condition that produces a voltage drop of at least 0.7 volt across R5 causes normally cut off Q4 to conduct and thereby establishes a constant current mode of operation. On overcurrent, this mode of

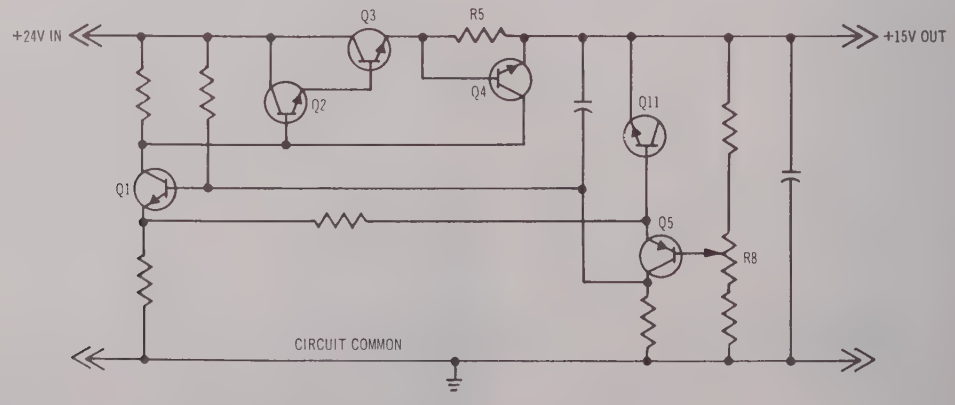

Figure 3-5. Typical Regulator Circuit

operation predominates over that of voltage regulation.

3-8. HIGH-VOLTAGE BOARD. The high-voltage board circuitry, consisting of two bridge rectifier networks, is shown in Figure 3-6 together with the external connections of the board. One rectifier, which has a series of resistors shunted by capacitors connected across its output, provides the output current of the instrument. The resistor-capacitor network is connected in series with the passing stage, A20Q3/Q4, the overcurrent-sensing resistor, A16R41, and the load on the instrument connected to the output-current terminals.

The rectifier input is provided by the secondary winding of a transformer, A20T2, the primary winding of which is connected in series with the other rectifier and a 115-volt, secondary winding on the power transformer, A20T1. The input of this other rectifier is connected to the preregulator switch, A20Q1/Q2, which is controlled from the preregulator control board, A16.

There are also four resistors on the high-voltage board that are connected to the first decade switch, S2.

3-9. REFERENCE-VOLTAGE UNIT

The reference-voltage unit consists of a constant-current preregulator in an electronically controlled oven. The oven is maintained at a temperature of 70^{+0}_{-5} degrees C and is stable to within 0.1 degree. The oven is powered by 15-volt and 40-volt windings on the power transformer. The reference-voltage circuit is powered

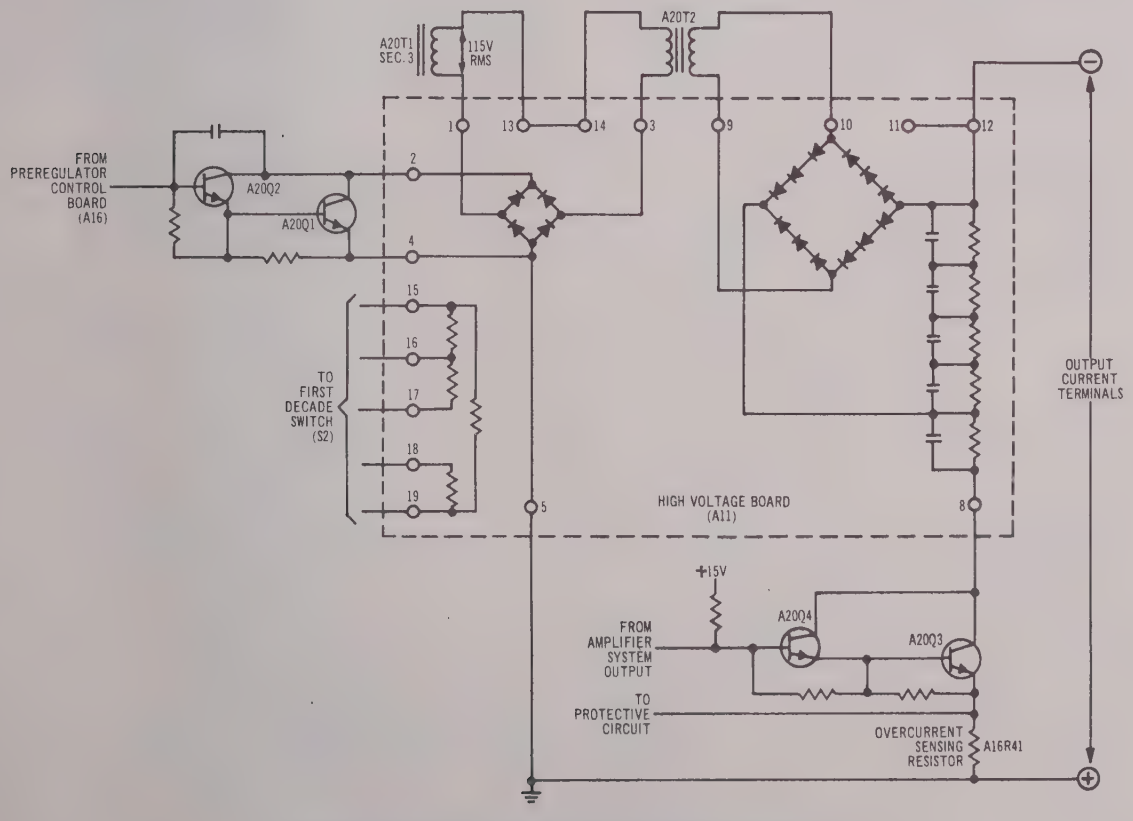

Figure 3-6. High Voltage Board Circuit

by 22 volts dc from the unregulated power supply. The output voltage of the reference circuit is approximately 6 volts dc.

3-10. VOLTAGE RANGE SWITCHING

The voltage-range circuit presents a constant load of 1.11 milliamperes to the output of the reference-voltage circuit regardless of the setting of the voltage-range switch. This is illustrated in Figure 3-7, which shows that whichever range is selected, two of the three sets of range resistors are connected across the output of the reference-voltage circuit, and one set of resistors is connected in series with the reference-voltage circuit and the decaded feedback network when the DC switch is in the ON position. All three sets of resistors are connected across the reference-voltage circuit when the DC switch is in the OFF position, thus removing the current through the feedback network. With no current flowing through the feedback network the output voltage of the instrument is zero.

3-11. DECADED-FEEDBACK NETWORK

The decaded-feedback network is the dc feedback circuit for the amplifier system and consists of seven decades of precision resistors that are connected in series or shorted out dependent on the settings of the decade dials. One of the three sensing currents, as determined by the voltage-range switching circuit, flows in the feedback resistors. The current in the selected resistors is as follows: 10-volt range, 0.01 milliampere; 100-volt range, 0.1 milliampere; 1000-volt range, 1 milliampere.

The product of the sensing current and the selected decaded-feedback resistors equals the voltage indicated by the range and decade dials. With the output voltage of the instrument at the level indicated by the dials the input of the amplifier system is virtually at zero potential with respect to circuit common (SENSE positive terminal). Any difference between the voltage developed across the selected resistors and

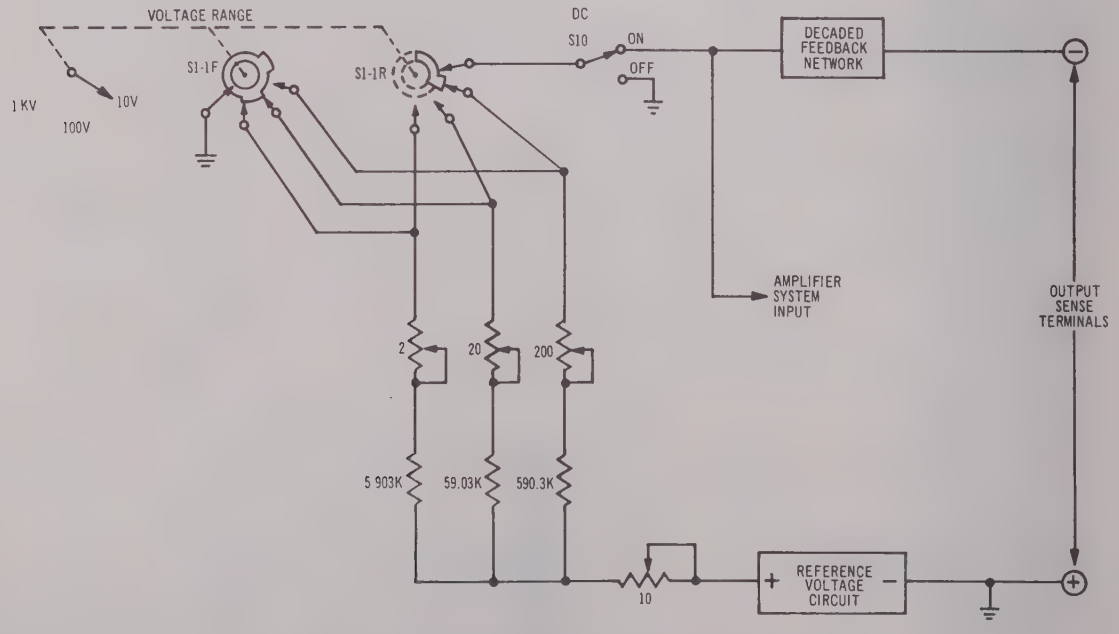

Figure 3-7. Voltage Range Switching Circuit

the output voltage of the instrument appears as an error voltage at the amplifier system input. The error voltage, which is applied to the carrier and wideband amplifiers, is rapidly reduced to negligible proportions by the large loop gain of the amplifier system, and the output voltage is driven to the prescribed level.

3-12. MODULATOR

The dc and lower frequency components of the error voltage are modulated by a chopper (contact modulator), A10G1, as indicated in Figure 3-8. The chopper is activated by 6.3 volts supplied by the power transformer. The modulated signal is applied to the two inputs of the carrier amplifier. The inputs are grounded alternately by the chopper, thereby producing rectangular-waveform signals that are opposite in phase relationship. The frequency of the signals is the same as that of the ac voltage activating the chopper (power line frequency).

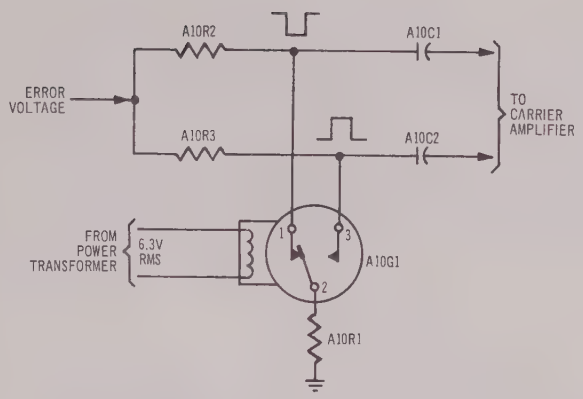

Figure 3-8. Modulator Circuit

3-13. CARRIER AMPLIFIER

The circuit of the carrier amplifier, Figure 3-9, is a high gain, differential, feedback amplifier consisting of four stages: a two-FET input stage Q1/Q2; two stages of amplification, Q3/Q4 and Q5/Q6, and a two-emitter-follower output stage, Q7/Q15. A dc feedback path from Q5 to Q1 is provided by R14 and R2. A second feedback path from Q6 to Q2 is provided by R58

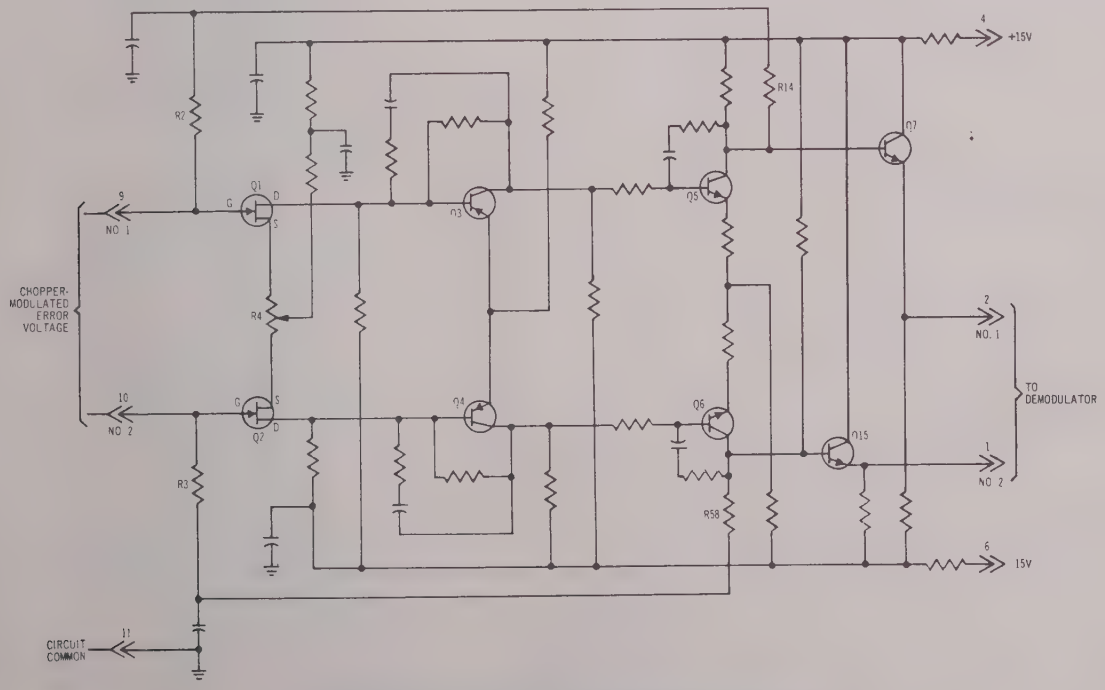

Figure 3-9. Carrier Amplifier Circuit

and R3. The input of the carrier amplifier is the chopper-modulated dc and lower-frequency components of the error voltage. The differential output of the amplifier, which consists of rectangular pulses, is applied to the demodulator. The amplitude of the pulses is adjustable by means of R4.

3-14. DEMODULATOR

The demodulator circuit, Figure 3-10, includes two transistors, A14Q12 and A14Q13, that function as switches. The switches are controlled by a 6.3-volt supply from secondary winding 5 of the power transformer, T1. The ac voltage is properly phased for full-wave, synchronous rectification of the rectangular-waveform outputs of the carrier amplifier. The output of the demodulator is of the same polarity and proportional to the dc and lower frequency components of the error voltage, and is combined with the output of the wideband amplifier at the dc amplifier input.

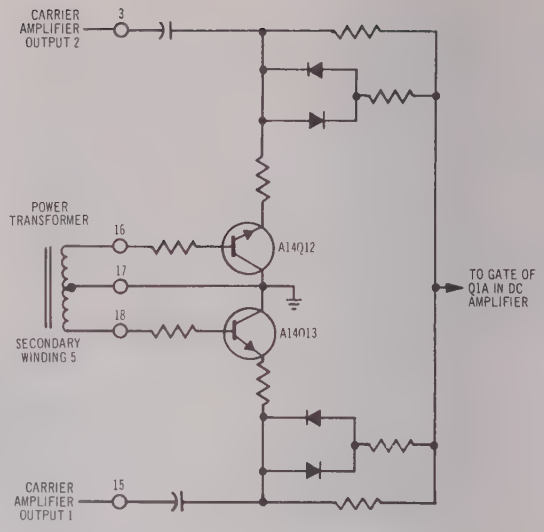

Figure 3-10. Demodulator Circuit

3-15. WIDEBAND AMPLIFIER

The circuit of the wideband amplifier, Figure 3-11, is a high gain, feedback amplifier consisting of four stages: a two-FET input stage, Q8/Q9; two amplification stages, Q10/Q11 and Q12/Q13; and an emitter follower output stage, Q14. The error

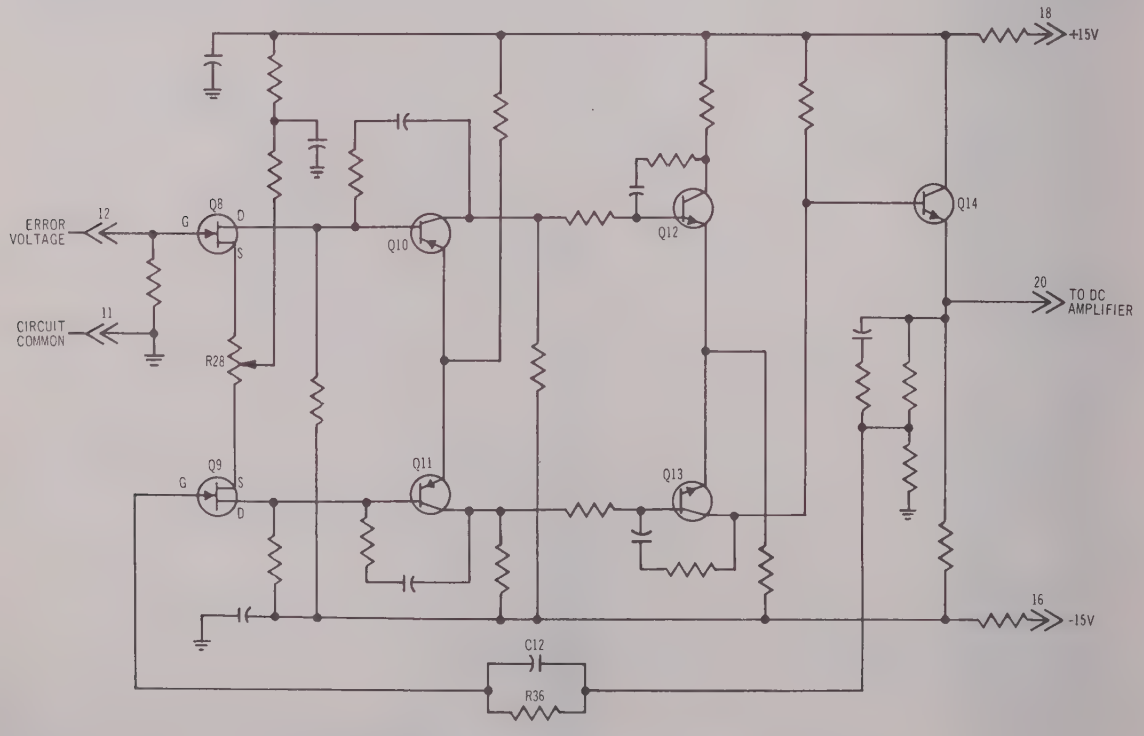

Figure 3-11. Wideband Amplifier Circuit

voltage is applied to Q8. A feedback path from Q14 to Q9 is provided by R36 and C12. The output of Q14 is combined with the output of the demodulator at the dc amplifier input. The wideband amplifier amplifies the higher frequency components of the error voltage. The amplitude of the wideband amplifier output is adjustable by means of R28.

3-16. DC AMPLIFIER

The circuit of the dc amplifier, Figure 3-12, is a high gain, feedback amplifier consisting of four stages: a two-FET input stage, Q1A/Q1B; two stages of amplification, Q2/Q3 and Q4/Q5; and an emitter follower output stage, Q6. The outputs of the demodulator and the wideband amplifier are combined at the input of Q1A to form a reconstituted signal proportional to the error voltage. A feedback path from Q6 to Q1B is provided by R51 and C7. The output of the dc amplifier is applied to the driver amplifier. The amplitude of the output is adjustable by means of R8.

3-17. DRIVER AMPLIFIER

The circuit of the driver amplifier, Figure 3-13, is a feedback amplifier consisting of three stages: a two-FET input stage, Q7/Q8; an amplification stage, Q9/Q10; and an emitter follower output stage, Q11. The output of the dc amplifier is applied to Q8. A feedback path is provided from Q11 to the gate of Q7. The output of the driver amplifier is fed to the base of A20Q4 in the passing circuit.

3-18. PREREGULATOR CONTROL

A functional block diagram of the preregulator control and associated circuits is shown in Figure 3-14, and the schematic diagram, provided for the purpose of troubleshooting, is shown in Figure 4-6. The function of the preregulator control is to limit the voltage across the passing stage to approximately 100 volts and to improve the efficiency of the instrument at low output voltages.

The output of the high-voltage, rectifier-circuit is automatically adjusted by the preregulator to a value of approximately 100 volts (positive peak) above the output voltage of the instrument. This "excess" voltage and all ripple appears across the passing stage, A20Q3/Q4.

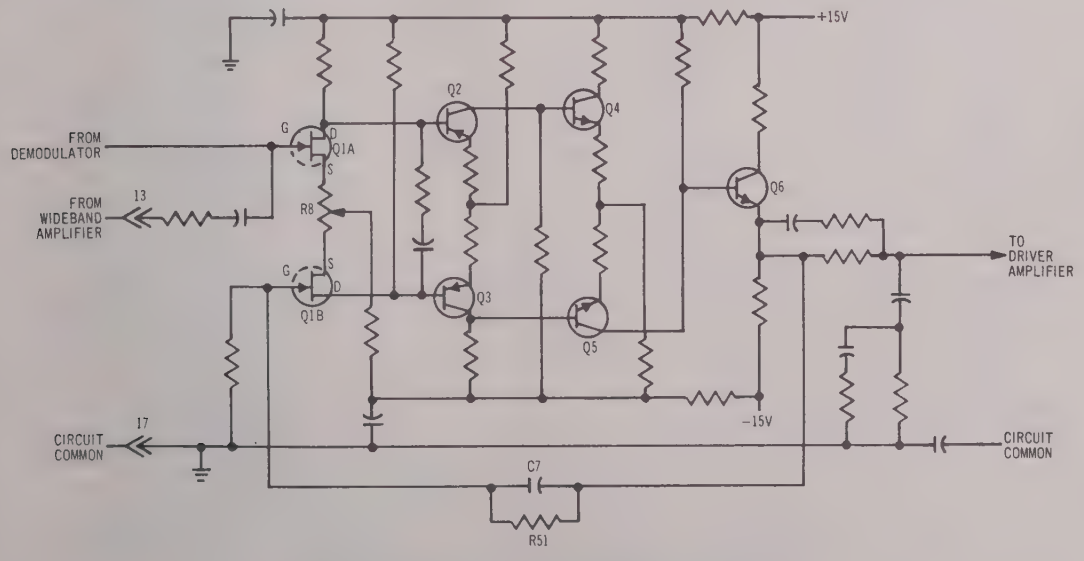

Figure 3-12. DC Amplifier Circuit

The output voltage of the high-voltage, rectifier-filter circuit is determined by the output voltage of the step-up transformer, A20T2. The input of A20T2 is controlled by an electronic switch, A20Q1/Q2, which regulates the portion of each half cycle of the 60-hertz supply that is applied to A20T2 from a secondary winding on the power transformer, A20T1.

Energy is supplied to the storage capacitors, A11C1 through C4 in the high-voltage, rectifier-filter circuit, during a brief portion of each half cycle of the 60-hertz sine wave, just as in any capacitor-input filter circuit. The difference here is that the energy is not necessarily supplied to the capacitors during the peak of the voltage waveform.

A winding on the power transformer, A20T1, drives a zero-crossing detector, A16Q1/Q2, which generates a trigger at the start of each half cycle of the ac-line voltage, as indicated by waveform B in Figure 3-15. The trigger sets the flip-flop, A16Q4/Q5, the output (waveform C) of which, applied through the driver, A16Q6, closes the electronic switch, A20Q1/Q2 (waveform D). The increasing sinewave voltage (waveform E) is applied through A20T2 to the high-voltage, rectifier-filter circuit.

When the output voltage of the rectifier exceeds the voltage across the capacitors, A11C1 through C4, the capacitors charge (waveform F). The increasing voltage across the capacitors also appears as an increasing voltage across the passing stage (waveform G) since the main voltage regulating loop operates on the passing stage to maintain the instrument output voltage constant.

The voltage across the passing stage is

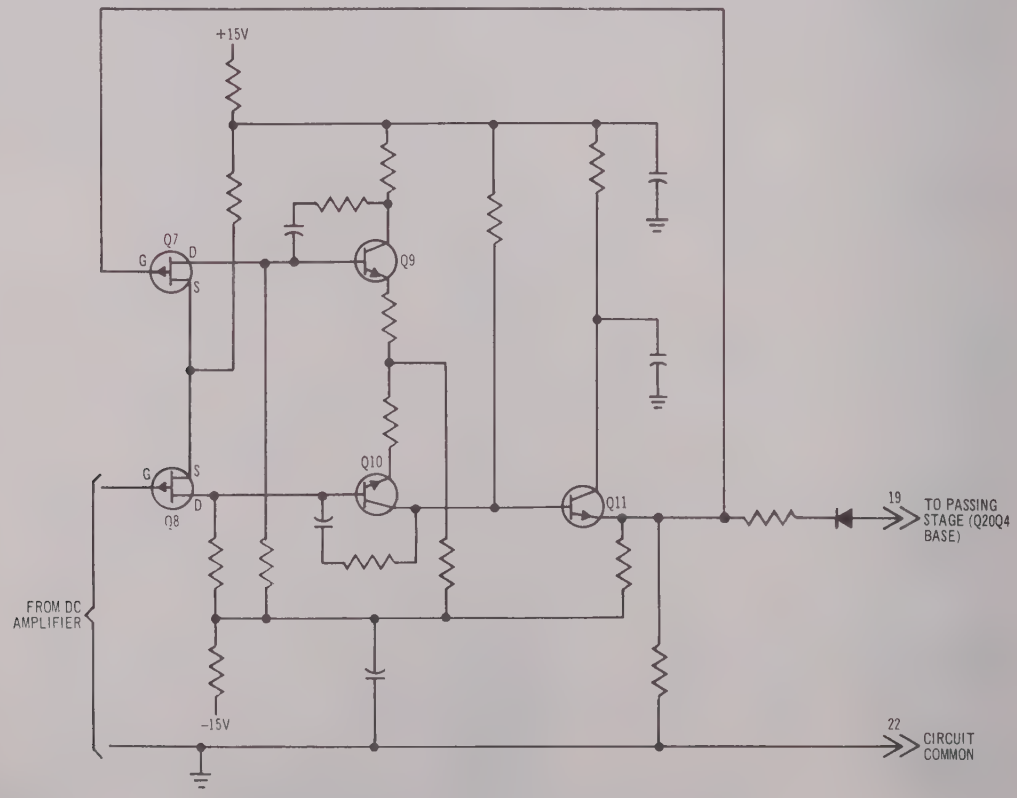

Figure 3-13. Driver Amplifier Circuit

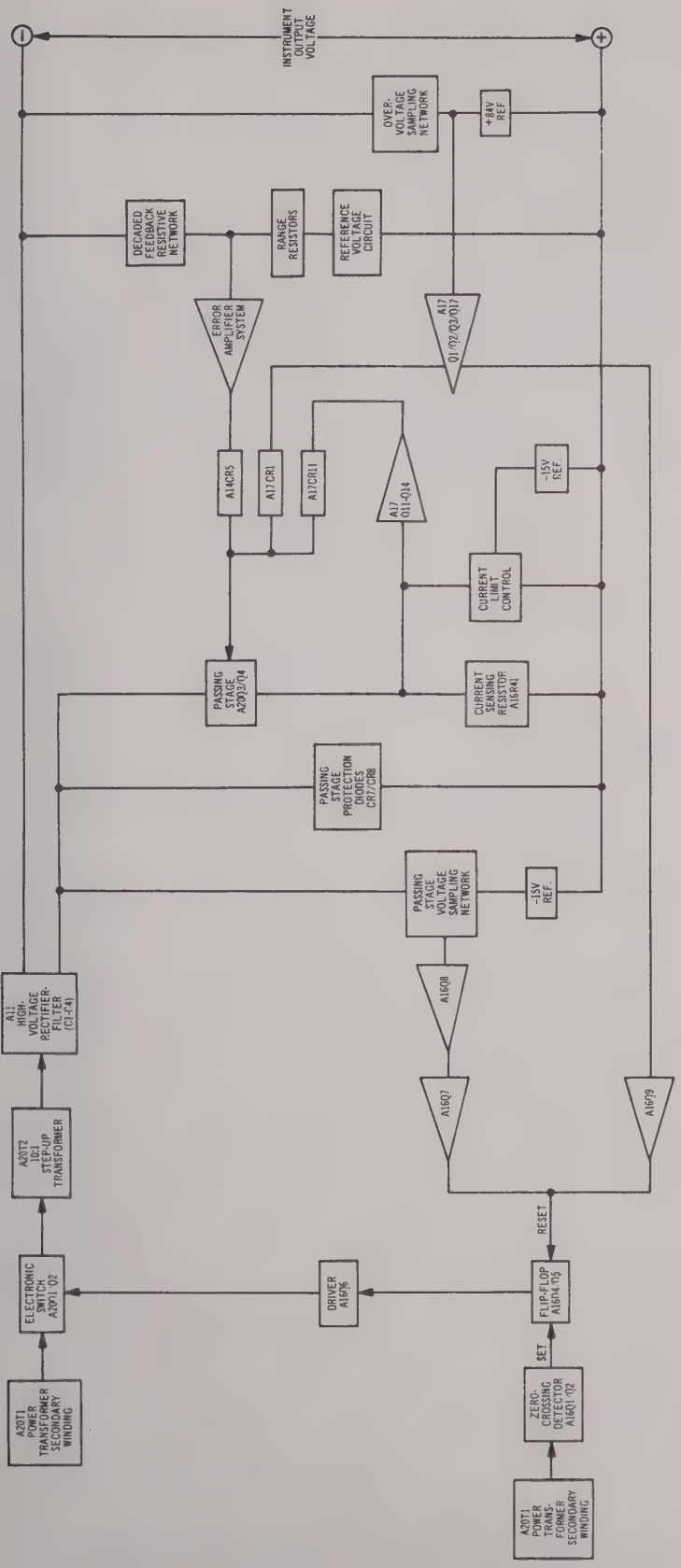

Figure 3-14. Preregulator Control and Protection Circuit Functional Block Diagram

sensed at the input of A16Q8, and when the voltage reaches approximately 100 volts A16Q8 causes A16Q7 to reset the flip-flop; this action, through the driver, opens the electronic switch, which stops any further increase in the amplitude of the pulse (waveform E) supplied by T2 to the high-voltage, rectifier-filter circuit.

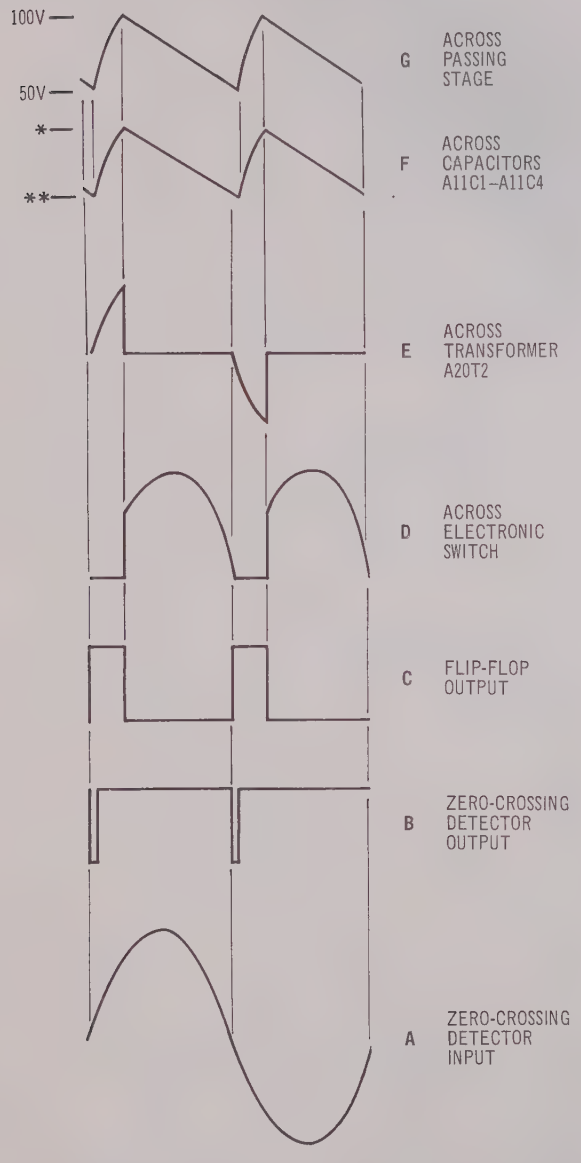
100V
50V
*
**
G ACROSS PASSING STAGE
F ACROSS CAPACITORS A11C1-A11C4
E ACROSS TRANSFORMER A20T2
D ACROSS ELECTRONIC SWITCH
C FLIP-FLOP OUTPUT
B ZERO-CROSSING DETECTOR OUTPUT
A ZERO-CROSSING DETECTOR INPUT
*THIS VOLTAGE LEVEL CORRESPONDS TO SELECTED OUTPUT VOLTAGE PLUS APPROXIMATELY 100 VOLTS
**THIS VOLTAGE LEVEL, AS COMPARED TO THE * LEVEL, IS FOR INSTRUMENT OUTPUT CURRENT OF APPROX. 50 mA AND CORRESPONDS TO OUTPUT VOLTAGE LEVEL PLUS APPROX. 50 VOLTS. THIS LEVEL DEPENDS ON OUTPUT CURRENT: GREATER THE CURRENT, LOWER THE LEVEL

Figure 3-15. Preregulator Control Voltage Waveforms

3-19. PROTECTIVE CIRCUIT

A functional block diagram of the protective circuit and associated circuitry is shown in Figure 3-14, and the schematic diagram, which is provided for the purpose of troubleshooting, is shown in Figure 4-6. Overvoltage protection is provided by a secondary voltage regulating loop. Overcurrent protection is provided by the instrument going from the normal voltage-regulating mode to a constant-current mode of operation.

3-20. OVERVOLTAGE PROTECTION. Overvoltage protection is provided by circuits that include an amplifier, A17Q1/Q2/Q3/Q17; the overvoltage sampling network; and the +84-volt reference, which constitute a secondary voltage-regulating loop operating through the passing stage, A20Q3/Q4, or the preregulator control described in paragraph 3-18. During overvoltage A17Q17 controls the passing stage through A17CR1. If the passing stage fails A17Q3 controls the preregulator through amplifier A16Q9.

The secondary regulating loop functions in a manner similar to the main regulating loop. By means of a set of resistors connected to the first and second decade switches and the range switch, (but separate from the precision resistors used for setting the instrument output voltage), the secondary loop is set to operate at a voltage a small percentage higher than that determined by the main voltage-regulating loop. In addition to its overvoltage protection function the secondary regulating loop also operates during transient conditions, such as occasioned by large, selected change in the instrument output voltage.

The operation of the secondary regulating loop limits the overshoot and rapidly brings the output voltage to the selected level. During normal voltage regulation the A17Q18/Q19 circuit keeps the LIMIT MODE indicator extinguished.

3-21. OVERCURRENT PROTECTION. Overcurrent protection is provided by a constant-current regulating loop that operates through the passing stage. This loop takes control away from the main and secondary voltage-regulating loops if the instrument output current attempts to exceed the level set by the CURRENT LIMIT control.

The instrument output current is sensed by the voltage drop across the current sensing resistor and compared with the reference voltage provided by the CURRENT LIMIT control. The difference in voltage is amplified by the A17Q11/Q12/Q13/Q14 circuit, the output of which drives the passing stage via diode A17CR11, maintaining the output current at a constant level. In this mode of operation the A17Q15/Q16 circuit lights the LIMIT MODE indicator.

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Section IV
MAINTENANCE

4–1. GENERAL

This section contains information and instructions for disassembly, parts location, preventive and corrective maintenance, troubleshooting, internal adjustments, and calibration. Maintenance support data includes the circuit descriptions in Section III, schematic diagrams, and lists of replacement parts.

4–2. DISASSEMBLY

WARNING

Do not attempt disassembly when the instrument is energized; if the outer cover plates are removed, shock hazard may exist unless certain precautions are taken (refer to paragraph 4-13).

The top cover plate and the bottom cover plate can be removed after releasing 12 screws in the top and 12 screws in the bottom of the instrument. The removal of these plates reveals the chassis, which has top and bottom glass-epoxy shields each secured by eight screws. When the shields are removed access to the plug-in, circuit boards and other subassemblies and components is available. The rear cover plate is secured by six screws. The front panel can be moved forward after removing two screws at each side or it can be tilted down after removing only the top screw of each pair. Only the three screws securing the hinged section of the top plate need be removed for recalibrating the instrument.

4–3. PARTS LOCATION

The locations of the plug-in boards and other subassemblies and some of the components are indicated in Figures 4-1 and 4-2. A top view of the instrument is shown in Figure 4-1 and a bottom view is shown in Figure 4-2. The etched-circuit boards are marked with the circuit reference designations of the components mounted on them.

4–4. PREVENTIVE MAINTENANCE

The instrument requires little routine maintenance other than keeping it clean. Inspect the interior periodically for cleanliness. Whenever it is cleaned internally, visually inspect the instrument for signs of deterioration.

4-5. GENERAL CLEANING

Clean the interior of the instrument at intervals determined by experience to minimize the accumulation of dust and lint. If available, compressed air is suitable for cleaning, otherwise use a soft-hair brush and a bench vacuum cleaner. However, if the former is used, take care not to cause damage by the use of excessive pressure. Cleaning of the front panel terminals should not be overlooked.

4-6. SWITCHES

Under normal operation the switches require no maintenance other than lubrication. Most maintenance methods are actually harmful and will shorten the life of a switch. Therefore, leave the switches alone unless maintenance due to adverse

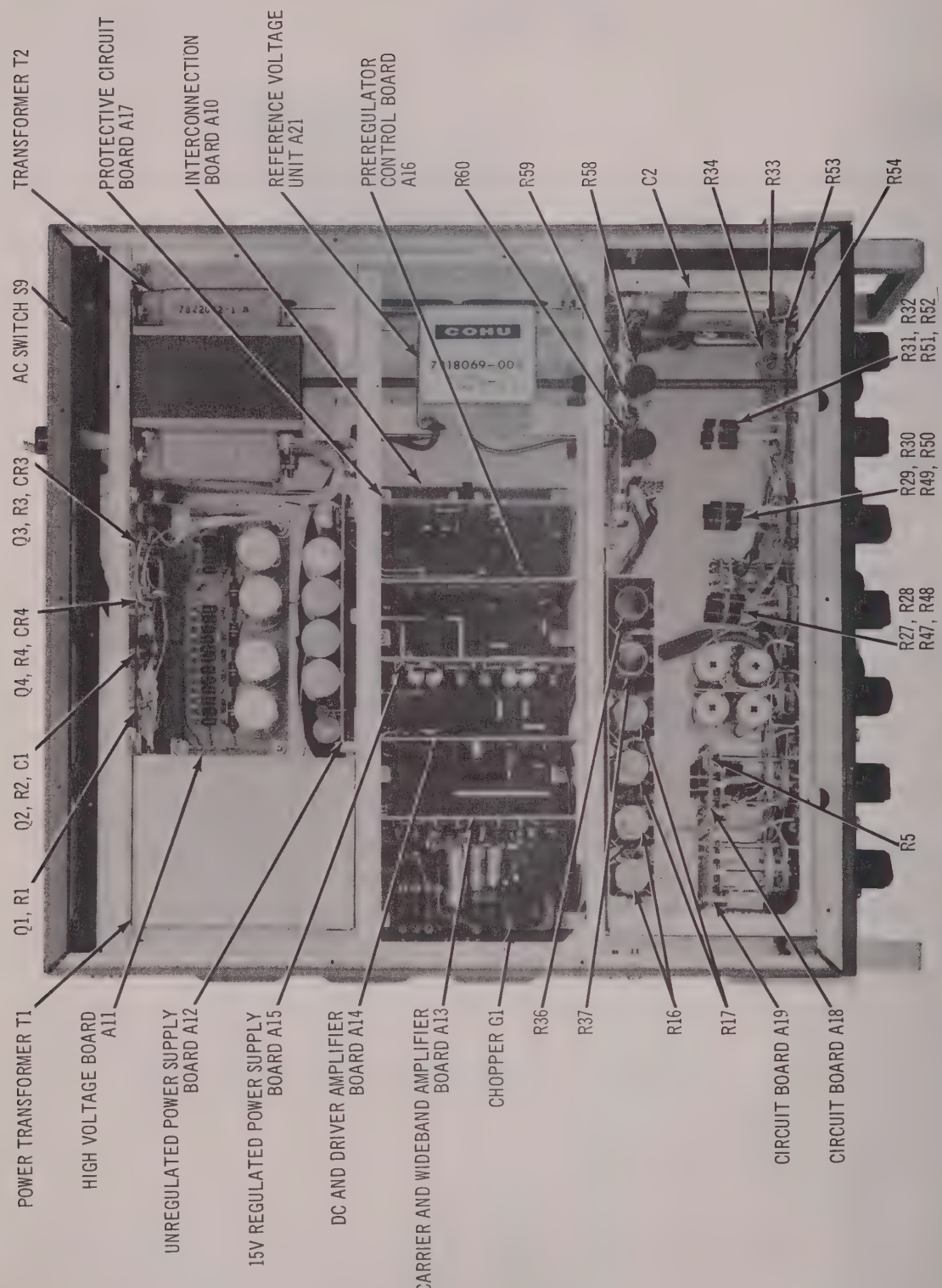


Figure 4-1. Subassembly and Component Locations, Top View

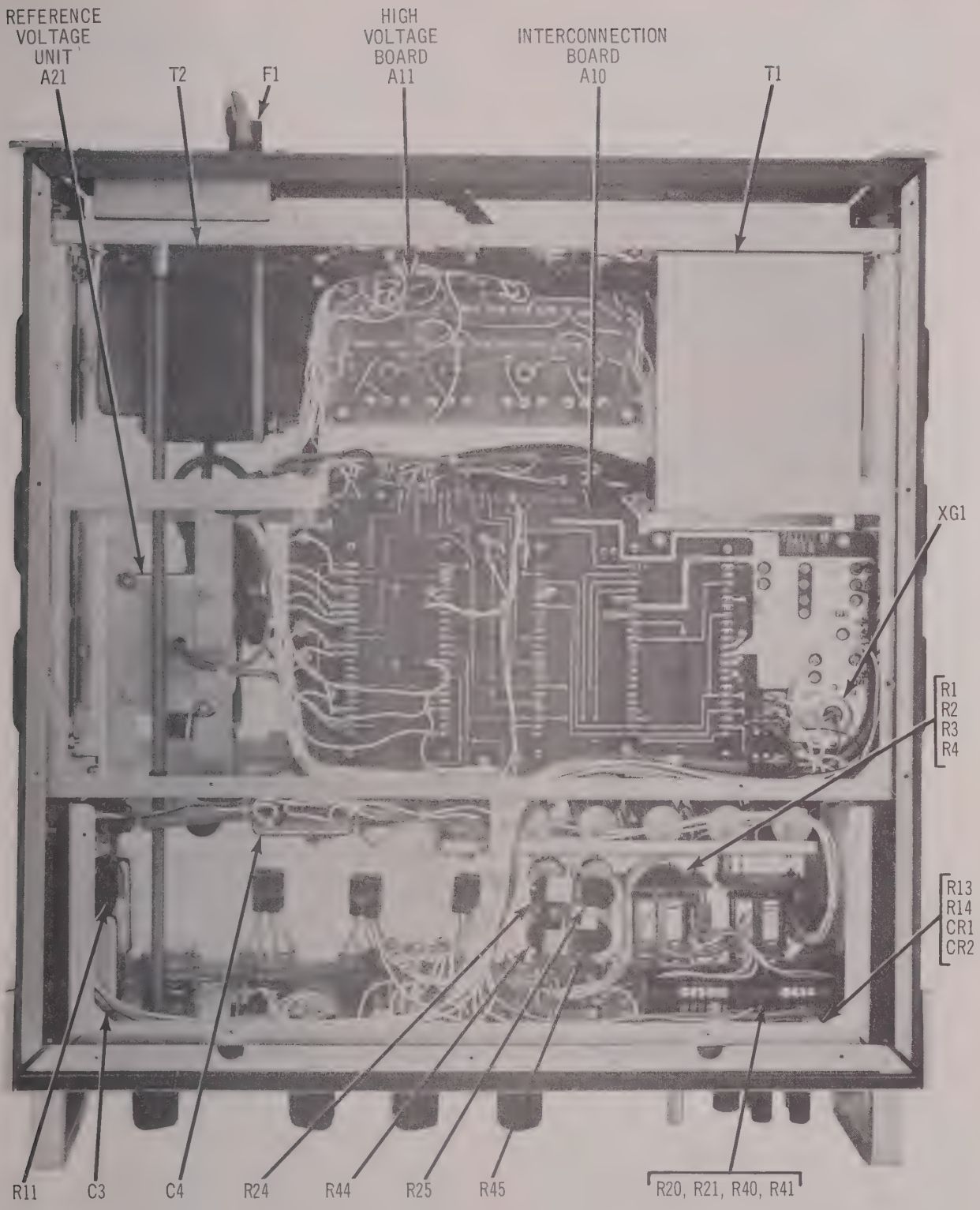


Figure 4-2. Subassembly and Component Locations, Bottom View

ambient conditions is absolutely necessary. In an excessively dusty or contaminated atmosphere occasional cleaning of the contacts may be beneficial. The contacts should be cleaned with a good degreasing solution such as carbon tetrachloride or methanol, allowed to dry, and then lightly lubricated with Oak No. 2008 grease or equivalent. It is recommended that the index assembly be lubricated after approximately every 1000 hours of operation.

4-7. CHOPPER

Output noise and stability characteristics may be seriously degraded by a malfunctioning chopper. The most valid test of the chopper's performance is to replace it with one known to be good. However, more information on the nature and function of choppers is presented in COHU Service Notes, Code No. 13-57A, "Chopper Checkout Procedures for COHU Equipment."

4-8. PERFORMANCE CHECK

The performance check of the instrument should include the test procedures in paragraph 4-9 and the calibration procedures in paragraph 4-10.

4-9. TEST PROCEDURES

The test procedure may be used for routine maintenance checks, to aid troubleshooting, and to test the instrument after repair, The test procedure is as follows:

a. Regulated Power Supply Board (A15)

Check voltage at following test points:

TP1, +15 ±0.25 volts. (Adjust R8.)

TP2, -15 ±0.25 volts. (Adjust R17.)

TP3, +15 ±0.25 volts. (Adjust R28.)

TP4, -15 ±0.25 volts. (Adjust R37.)

b. ACA and WBA Board (A13)

1. Carrier Amplifier

Check that voltages at test points TP1 and TP2 are within 2 volts of each other. (Adjust R4.)

2. Wideband Amplifier

Check that voltages at TP3 and TP4 are within 2 volts of each other. (Adjust R28.)

c. DC and Driver Amplifier Board (A14)

Check that voltages at test points TP4 and TP5 are within 2 volts of each other. (Adjust R8.) TP3 = 5.8V TP1 = 1.2V TP2 = 0V

d. Overvoltage Protection

1. Remove DC and driver amplifier board from instrument.

2. Set RANGE switch to 10 and decade dials to any voltage. Output voltage of instrument should measure 6 volts. (Adjust R9 on protective circuit board, A17.)

3. Set RANGE switch to 1000 and decade dials to 800 volts. Output voltage of instrument should measure 880 ±20 volts. (Adjust R2 on unregulated power supply board, A12.)

4-10. CALIBRATION

The instrument is calibrated using a procedure consisting of three parts: zero-volt-output adjustments, linearization of the decaded-feedback resistance and voltage ranges, and an accuracy adjustment. Linearization of the decaded-feedback resistance adjusts the ratio of the individual resistors in the three most significant decades to the standard resistors in the fourth decade; this gives ratio errors of

less than 0.0005 percent for the top three decades. The linearization adjustments are made using a variable supply of stable voltage. After linearization, the accuracy adjustment standardizes the instrument to a local voltage standard. Calibration should be performed at standard reference conditions (refer to paragraph 1-3).

4-11. CALIBRATION EQUIPMENT

The following equipment is required for calibrating the instrument:

a. An auxiliary dc supply of stable, variable voltage, such as another Model 355 or other dc voltage standard or calibrator of comparable short term stability and resolution.

b. A galvanometer with at least 10-microvolt full-scale deflection, such as COHU Model 208R or other instrument of comparable sensitivity.

c. A voltage standard, such as a certified, saturated standard cell or a bank of normal cells.

d. A small, insulated screwdriver or other tool suitable for adjusting trimming resistors.

4-12. CALIBRATION PROCEDURE

When performing the calibration procedure, operate all equipment in accordance with the instructions in the respective technical manuals, and set the galvanometer to the appropriate range for the best sensitivity. Perform the calibration procedure in the following order:

a. Preliminary Procedure

1. Open hinged, front part of top cover plate.

2. Set each decade dial to 0.

3. Set DC switch to ON.

4. Set CURRENT LIMIT control to MAX.

5. Energize equipment and allow at least 30 minutes for stabilization.

b. Zero-Volt-Output Adjustments

1. Connect instrument to galvanometer as shown in Figure 4-3.

2. Disconnect galvanometer leads at terminals of instrument and short disconnected ends of leads. Zero galvanometer on 10-microvolt range. Remove short and reconnect leads.

3. Set RANGE switch to 10 and adjust R7 to obtain zero-volt indication on galvanometer.

4. Set RANGE switch to 100 and adjust R6 for zero-volt indication.

5. Set RANGE switch to 1000 and adjust R5 for zero-volt indication.

c. Decaded-Feedback Resistance and Voltage Range Linearity Adjustments

1. Connect instrument to galvanometer and auxiliary supply as in Figure 4-4, which shows connections when auxiliary supply is another Model 355.

2. Disconnect galvanometer leads at terminals of instrument and auxiliary supply and short disconnected ends of leads. Zero galvanometer on 10-microvolt range. Remove short and reconnect leads.

3. First linearize decaded-feedback

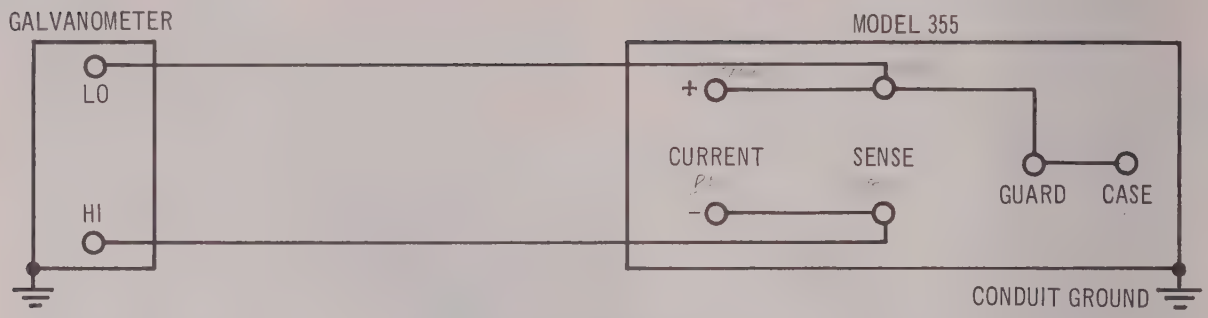


Figure 4-3. Zero-Volt-Output-Adjustment Calibration Setup

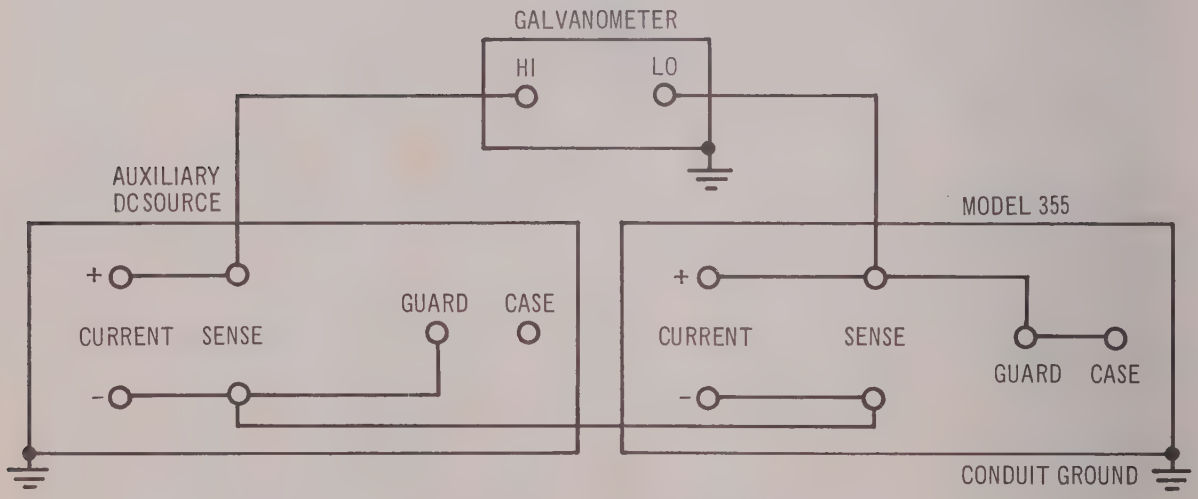


Figure 4-4. Linearity-Adjustment Calibration Setup

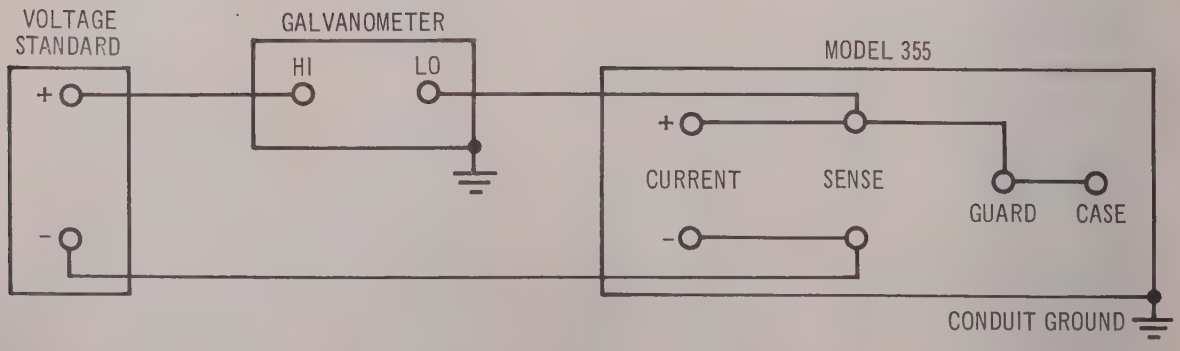


Figure 4-5. Accuracy-Adjustment Calibration Setup

Table 4-1. Linearization Procedure

Step	a Set Decade Dials To:	b Set Auxiliary Supply To:	c Adjust Auxiliary Supply For:	d Set Decade Dials To:	e Adjust Resistor For Same Null as Obtained In Column c Within Limits Indicated:	
1	000.X000	1V	↑ Galvanometer null ↓	001.0000	R43	±3 μV
2	001.X000	2V		002.0000	R46	±6 μV
3	003.X000	4V		004.0000	R23	±12 μV
4	007.X000	8V		008.0000	R26	±24 μV
5	00.X0000	1V		01.00000	R39	±3 μV
6	01.X0000	2V		02.00000	R42	±3 μV
7	03.X0000	4V		04.00000	R19	±4 μV
8	07.X0000	8V		08.00000	R22	±8 μV
9	0.X00000	1V		1.000000	R35	±1 μV
10	1.X00000	2V		2.000000	R38	±2 μV
11	3.X00000	4V		4.000000	R15	±4 μV
12	7.X00000	8V		8.000000	R18	±8 μV
13	*10.000000	10V	null	0X.00000	R56	±10 μV
14	*100.00000	100V	null	100.0000	R57	±100 μV
15	010.0000	10V	null	*10.000000	R55	±10 μV
16	Repeat steps 13, 14, and 15 until no further adjustment is necessary					

*Extreme left dial at 10

resistance by performing steps 1 through 12 in Table 4-1 and then linearize voltage ranges by performing steps 13 through 16. For each step follow instructions in columns a through e in sequence.

d. Accuracy Adjustment

1. Set decade dials to indicate voltage of local voltage standard.
2. Connect instrument to galvanometer and voltage standard as in Figure 4-5.

3. Disconnect galvanometer leads at terminals of instrument and voltage standard and short disconnected ends of leads. Zero galvanometer on 10-microvolt range. Remove short and reconnect leads.

4. Adjust R61 to obtain a null.

4-13. TROUBLESHOOTING

WARNING

To minimize shock hazard when troubleshooting with the instrument energized, connect SENSE positive and GUARD terminals to the metal terminal (ground). This provides a negative output and ensures that the selected output voltage is not present between the chassis and conduit ground.

Familiarity with the operation and the circuits of the instrument is advisable before troubleshooting is attempted. Knowing how the instrument functions, the general area within which a fault exists sometimes can be determined simply by operating the controls and noting the results. Try this as a first step and attempt to locate the fault by checking for overheated components, discolored resistors, broken wires, etc. If this method fails to give some indication of the trouble a systematic check of the circuits may be necessary.

4-14. LOCALIZING TROUBLE

Before making a complete systematic check of the instrument circuits it would be advisable to first investigate the preregulator control and protective circuits. To facilitate troubleshooting these circuits Figure 4-6 is provided, which combines in one diagram the preregulator control, the protective circuits, the high-voltage board, the passing stage, and other closely associated circuits. Signal flow paths through the amplifier system are indicated in Figure 4-7. The main schematic diagram of the instrument is in Figure 4-16.

4-15. LOCATING FAULTS

When trouble has been localized to a particular area, such as a circuit board or stage, locate the fault by employing the usual troubleshooting methods. Systematically check the circuits of the suspected area with the aid of the appropriate schematic diagram, Figures 4-8 through 4-15.

4-16. CORRECTIVE MAINTENANCE

When troubleshooting or performing corrective maintenance the following points should be borne in mind:

a. It is recommended that no attempt be made to troubleshoot the reference voltage unit. Since special testing is necessary to correct a defective unit, a reference unit suspected of being defective should be replaced.

b. The chopper is of the plug-in type and easily replaceable. The most valid performance test of a chopper is to replace it with one known to be good. Do not replace the chopper with the instrument turned on.

c. If troubleshooting indicates that a circuit board is faulty, replacing the board with a spare may be the quickest way to restore the instrument to service. Do not replace circuit boards with the instrument turned on.

d. After repair, certain readjustments may be required (refer to paragraph 4-9).

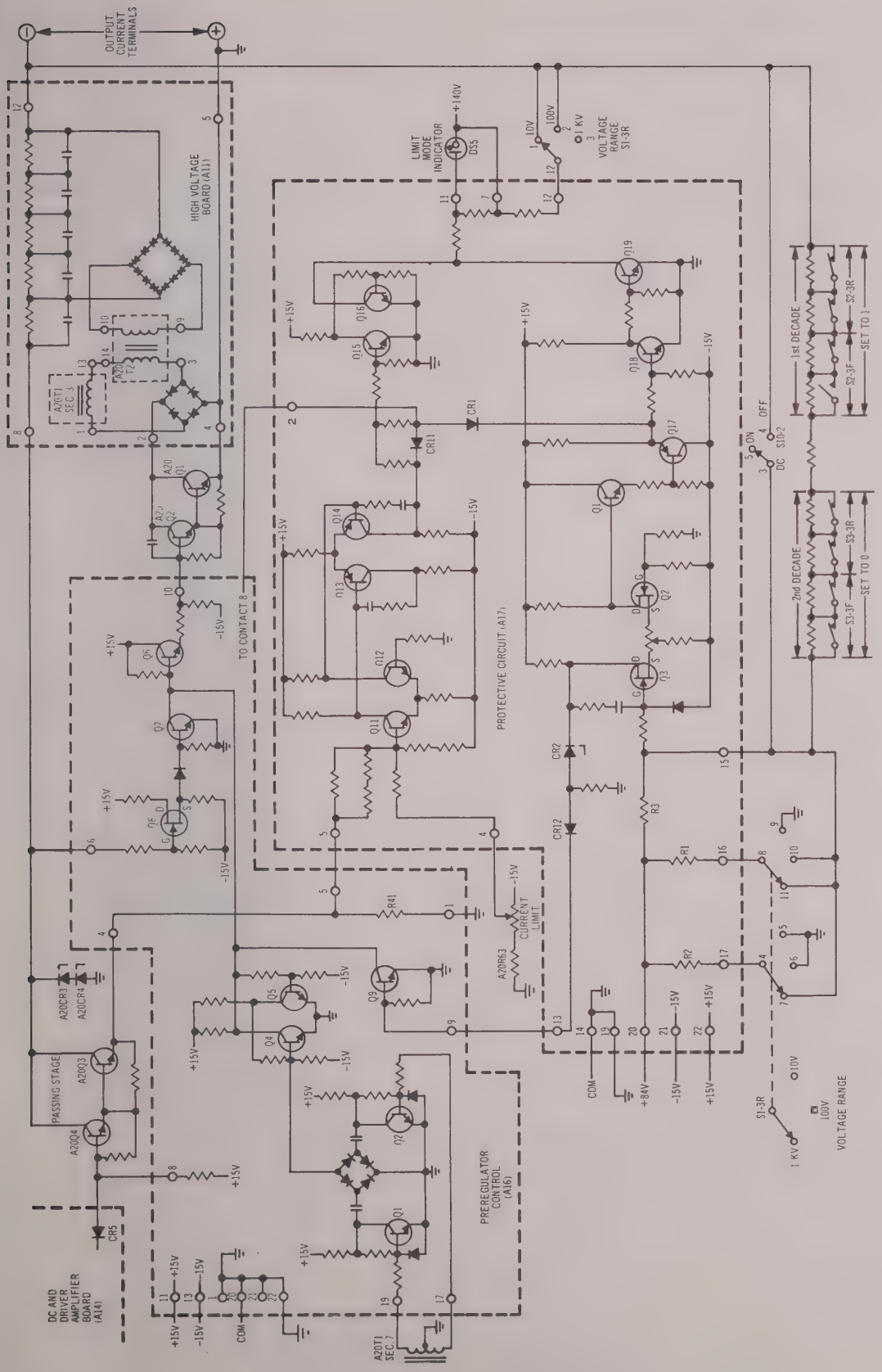


Figure 4-6. Preregulator and Protective Circuits

e. Observe the usual precautions when handling or soldering the printed circuit boards.

4-17. REPLACEMENT PARTS

Lists of replacement parts, arranged alphanumerically according to circuit reference designation, are contained in Tables 4-2 through 4-11.

NOTE

If the type, value, etc., of a component to be replaced is different from that given in the tables, make the replacement using the component listed.

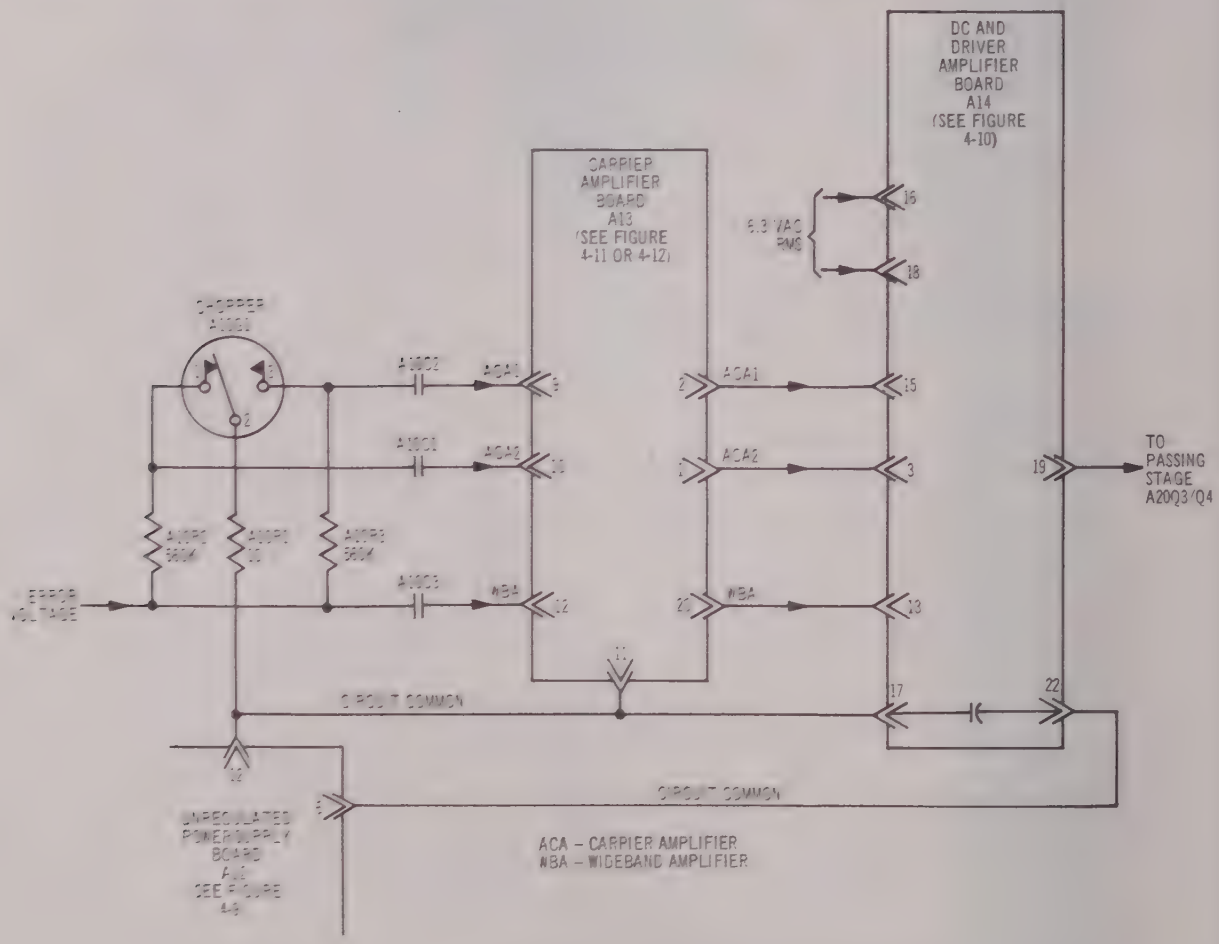

DC AND DRIVER AMPLIFIER BOARD A14 (SEE FIGURE 4-10)
CARRIER AMPLIFIER BOARD A13 (SEE FIGURE 4-11 OR 4-12)
6.3 VAC RMS
ACA1
ACA2
WBA
TO PASSING STAGE A20Q3/Q4
ERROR VOLTAGE
CIRCUIT COMMON
UNREGULATED POWER SUPPLY BOARD A4 (SEE FIGURE 4-9)
ACA – CARRIER AMPLIFIER
WBA – WIDEBAND AMPLIFIER

Figure 4-7. Amplifier System Signal Flow Diagram

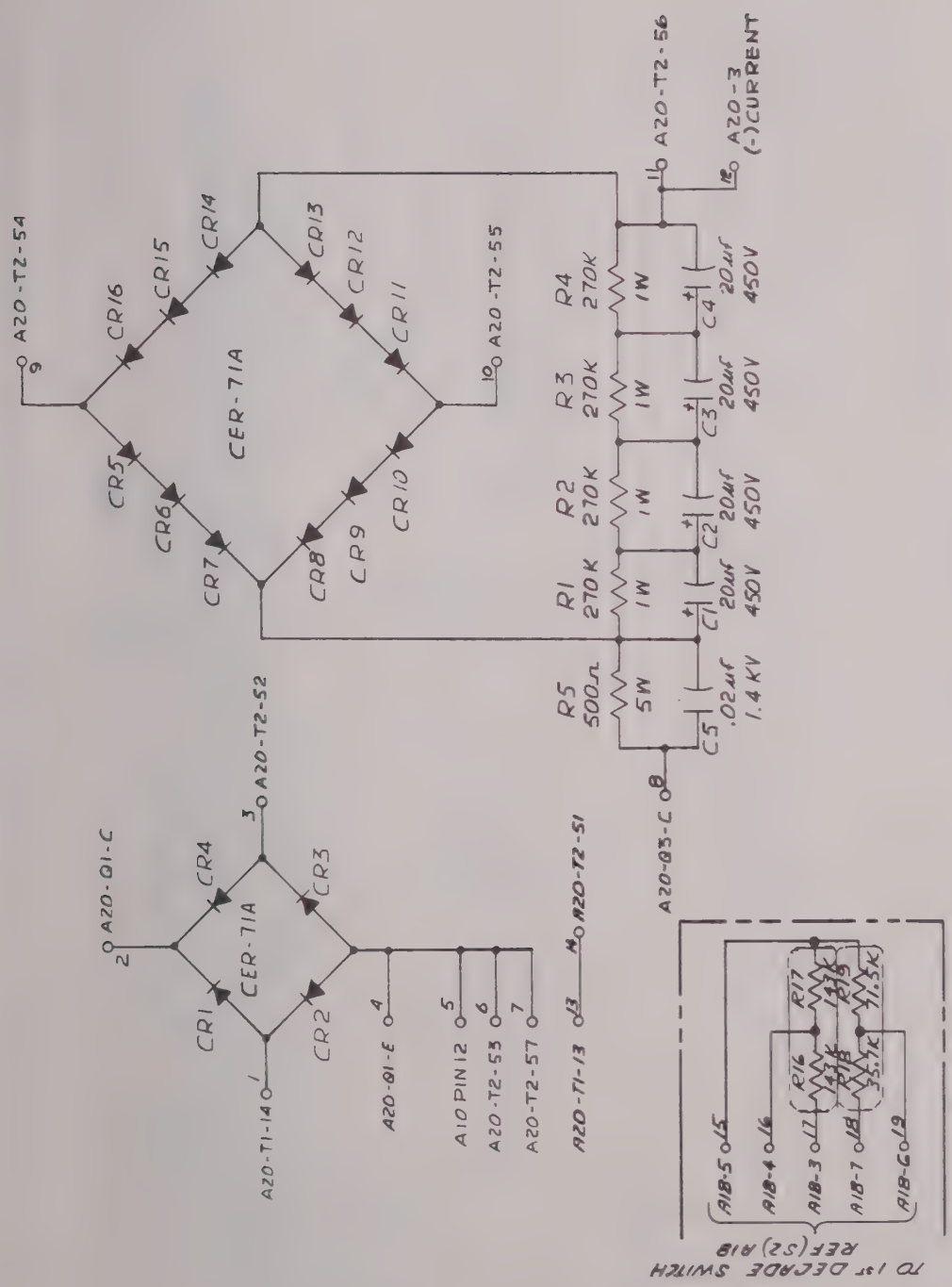
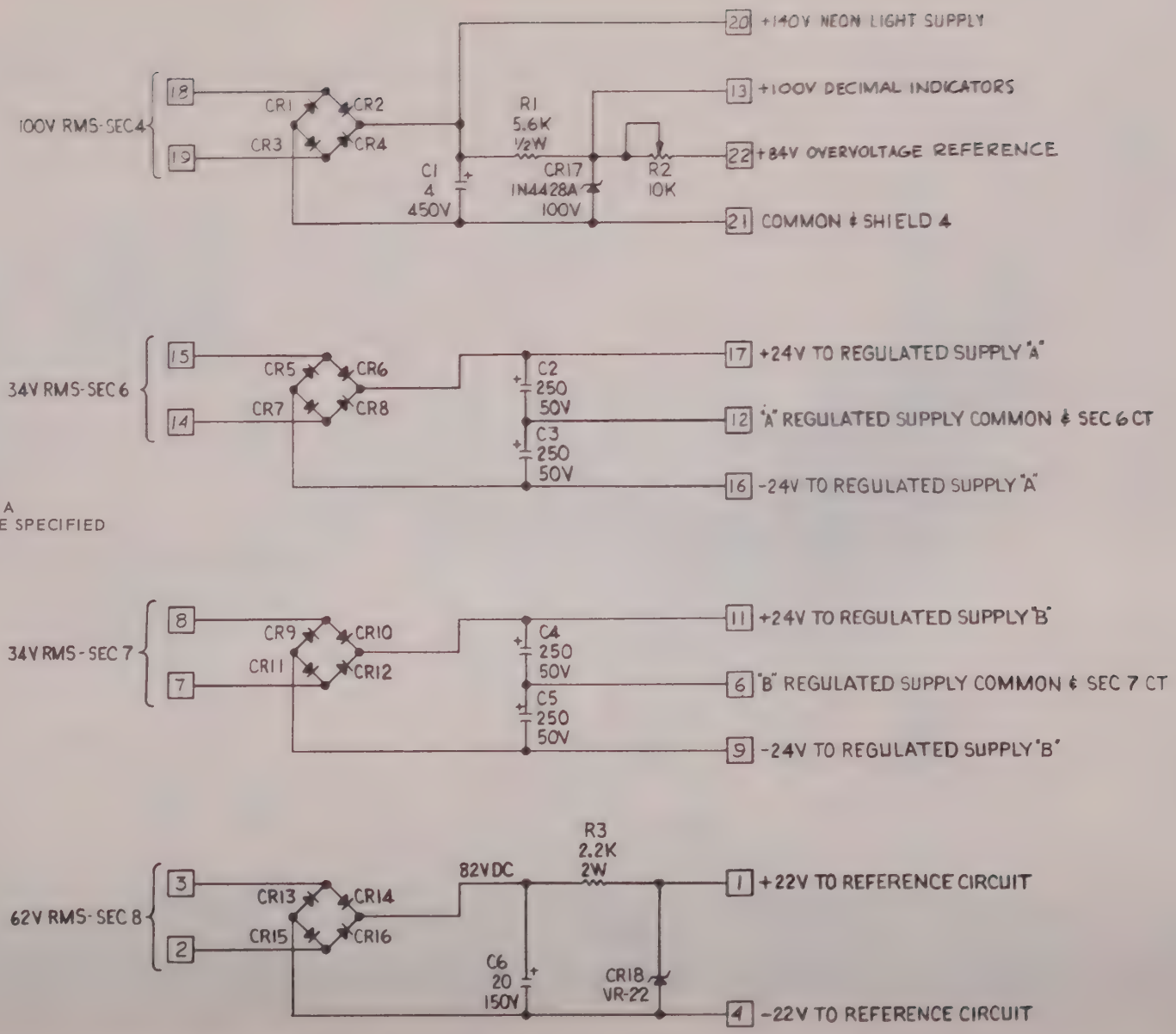
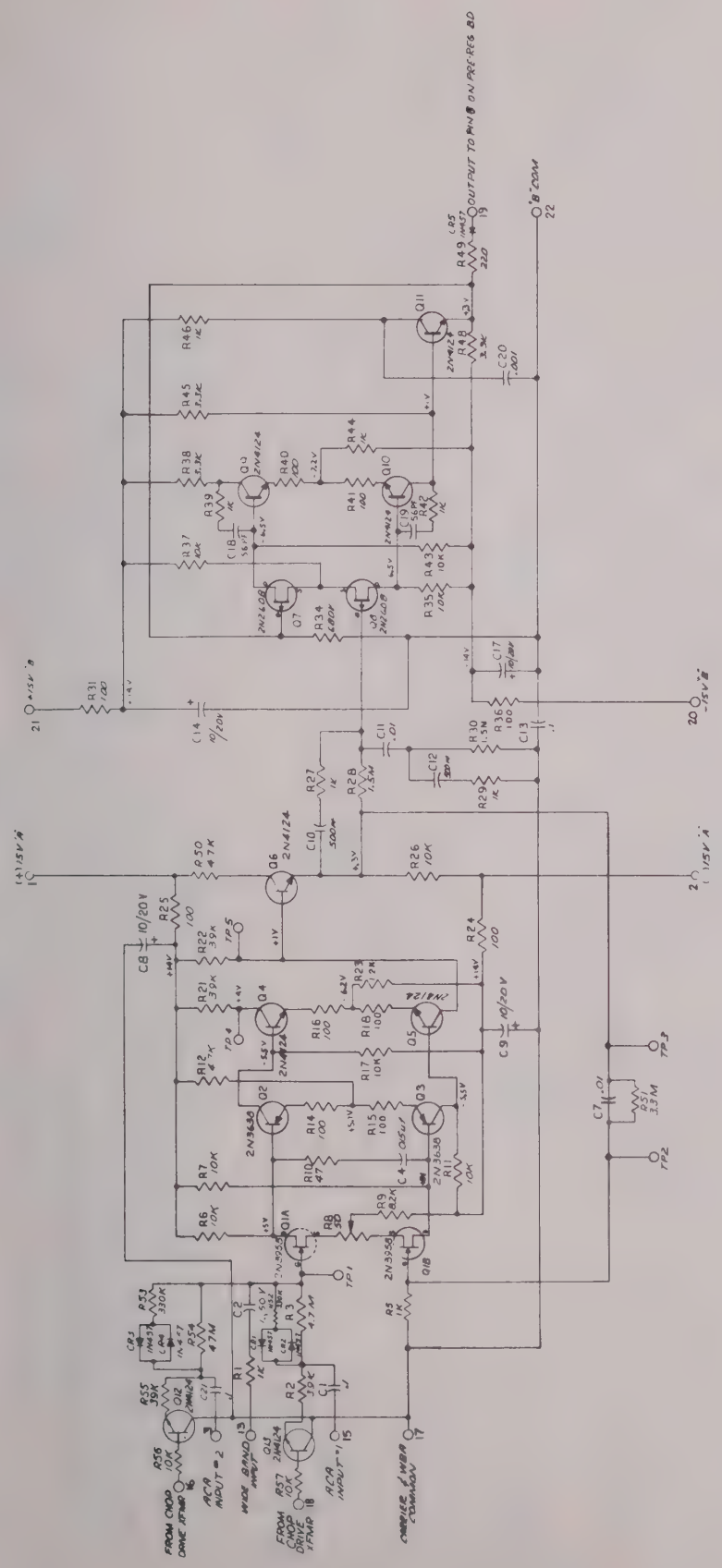


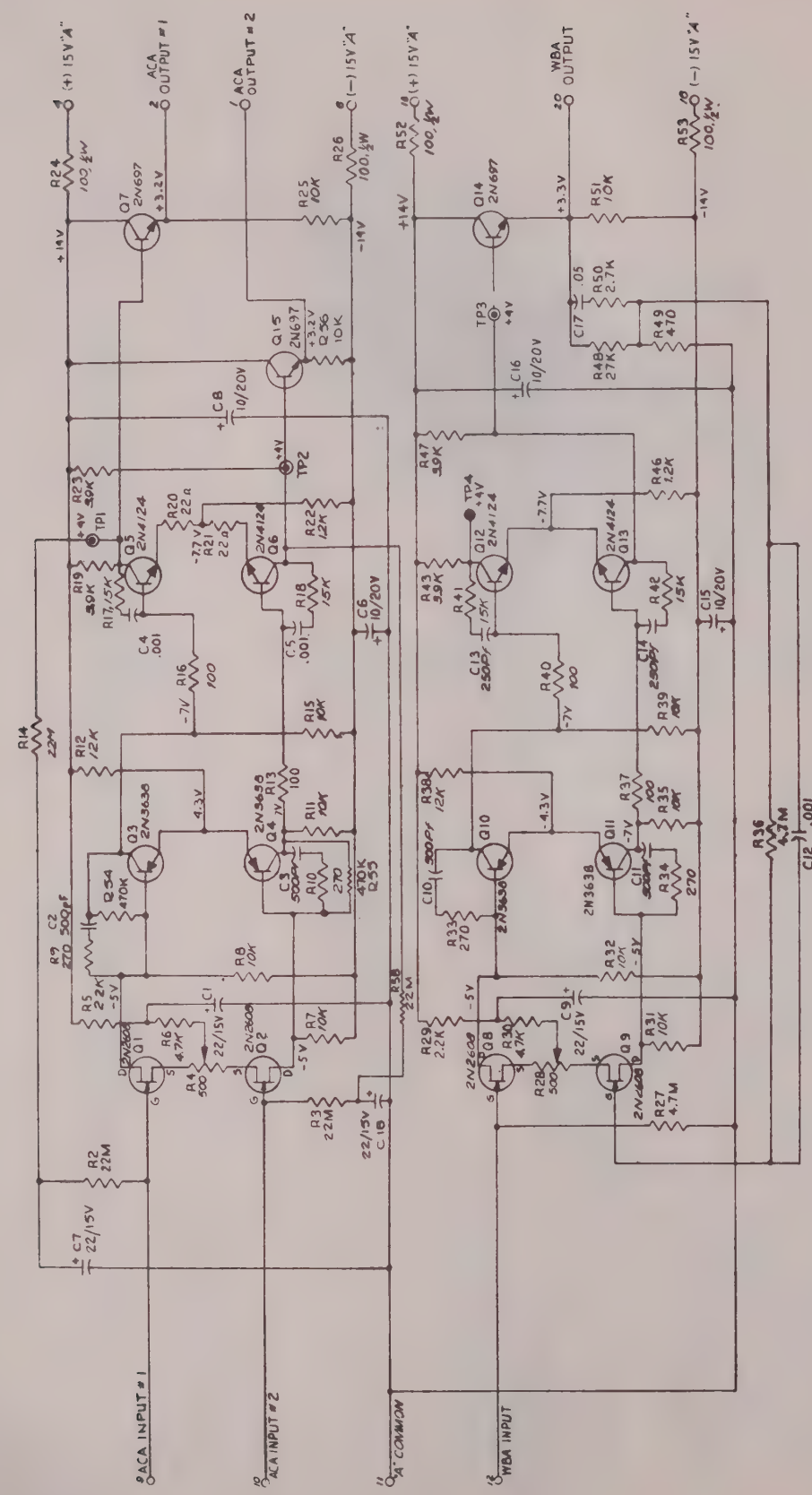
Figure 4-8. High Voltage Board (A11) Schematic Diagram (Drawing No. C7823110A)



2. REF. ASSEMBLY NO. A12
1. ALL DIODES ARE CER-71A
NOTES: UNLESS OTHERWISE SPECIFIED

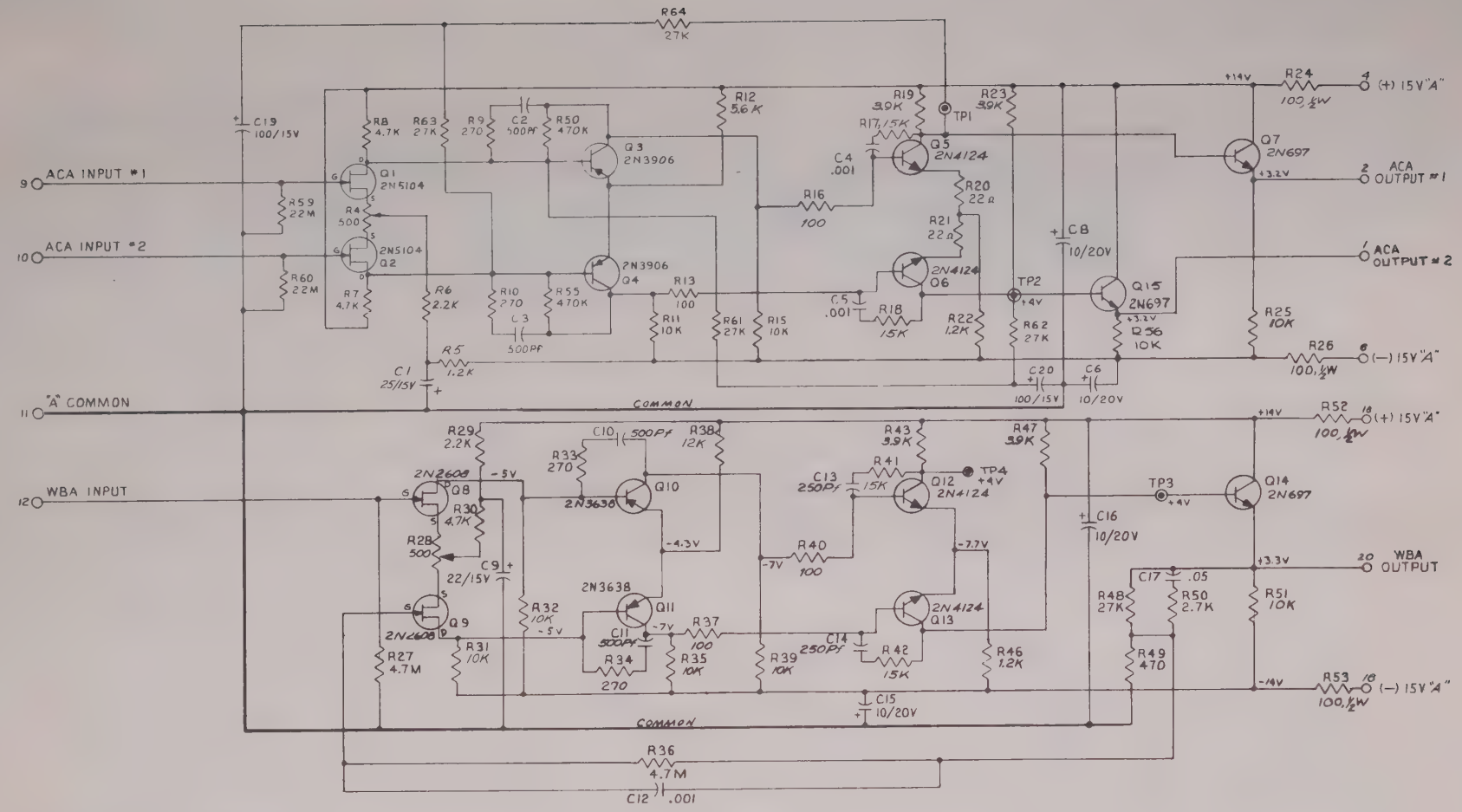
Figure 4-9. Unregulated Power Supply Board (A12) Schematic Diagram (Drawing No. D7822400A)


NOTES: UNLESS OTHERWISE SPECIFIED
1. RESISTOR VALUES IN OHMS & WATT
2. CAPACITOR VALUES IN MICROFARADS
3 ASSY. REF A4
OUTPUT TO PWB ON PREAMP BD
+15V A
-15V A
+15V B
-15V B
B COM
FROM CHOP DRIVE AMP
FROM CHOP DRIVE AMP
CHOPPER/MIXER COMMON
AGC INPUT = 1
AGC INPUT = 2
WIDE BAND
2N3638
2N3638
2N3638
2N3638
2N4124
2N4124
2N4124
2N4124
2N4124
2N4124
2N4124
2N4124
2N3958
2N3958
2N4250
2N4250
2N4250



NOTES: UNLESS OTHERWISE SPECIFIED
1. RESISTOR VALUES IN OHMS, ½ WATT.
2 CAPACITOR VALUES IN MICROFARADS.
3 REF ASSY NO. A13

Figure 4-11. Carrier and Wideband Amplifiers Board (A13) Schematic Diagram for Instruments Prior to Number 1-0085 (Drawing No. D7822600A)



4. Q1 AND Q2 ARE MATCHED PAIR
3. REF. ASSEMBLY NO. A13
2. CAPACITOR VALUES IN MICROFARADS
1. RESISTOR VALUES IN OHMS, ¼ WATT

NOTES: UNLESS OTHERWISE SPECIFIED

Figure 4-12. Carrier and Wideband Amplifiers Board (A13) Schematic Diagram for Instruments Numbered 1-0085 and Higher (Drawing No. D7822600B)

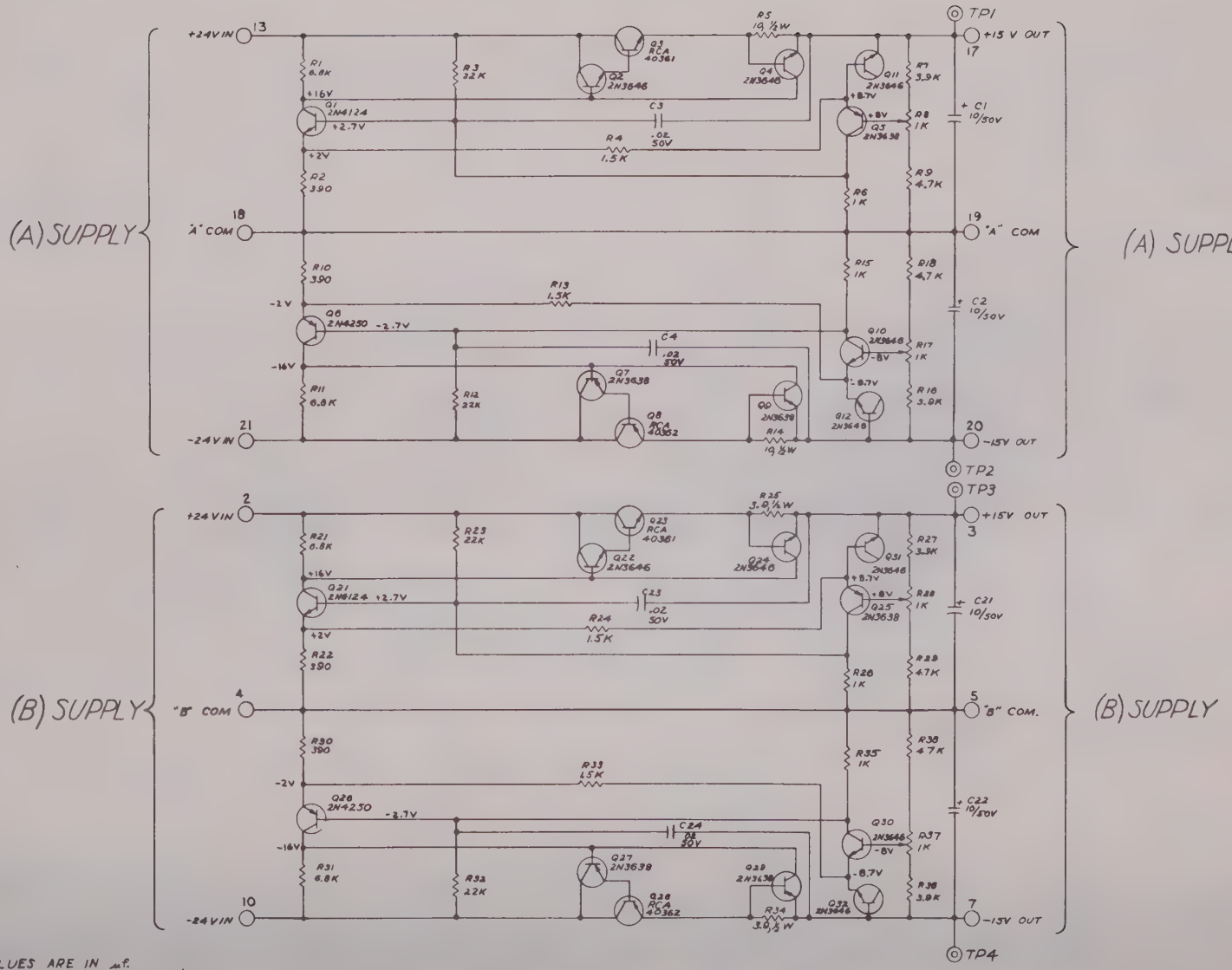
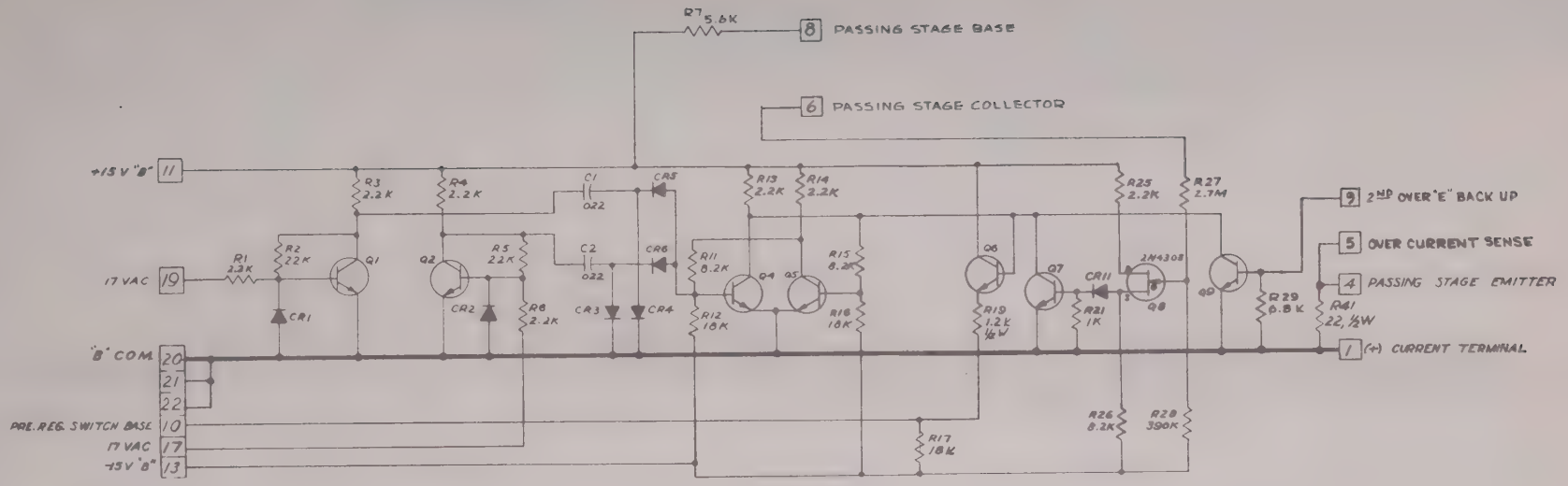


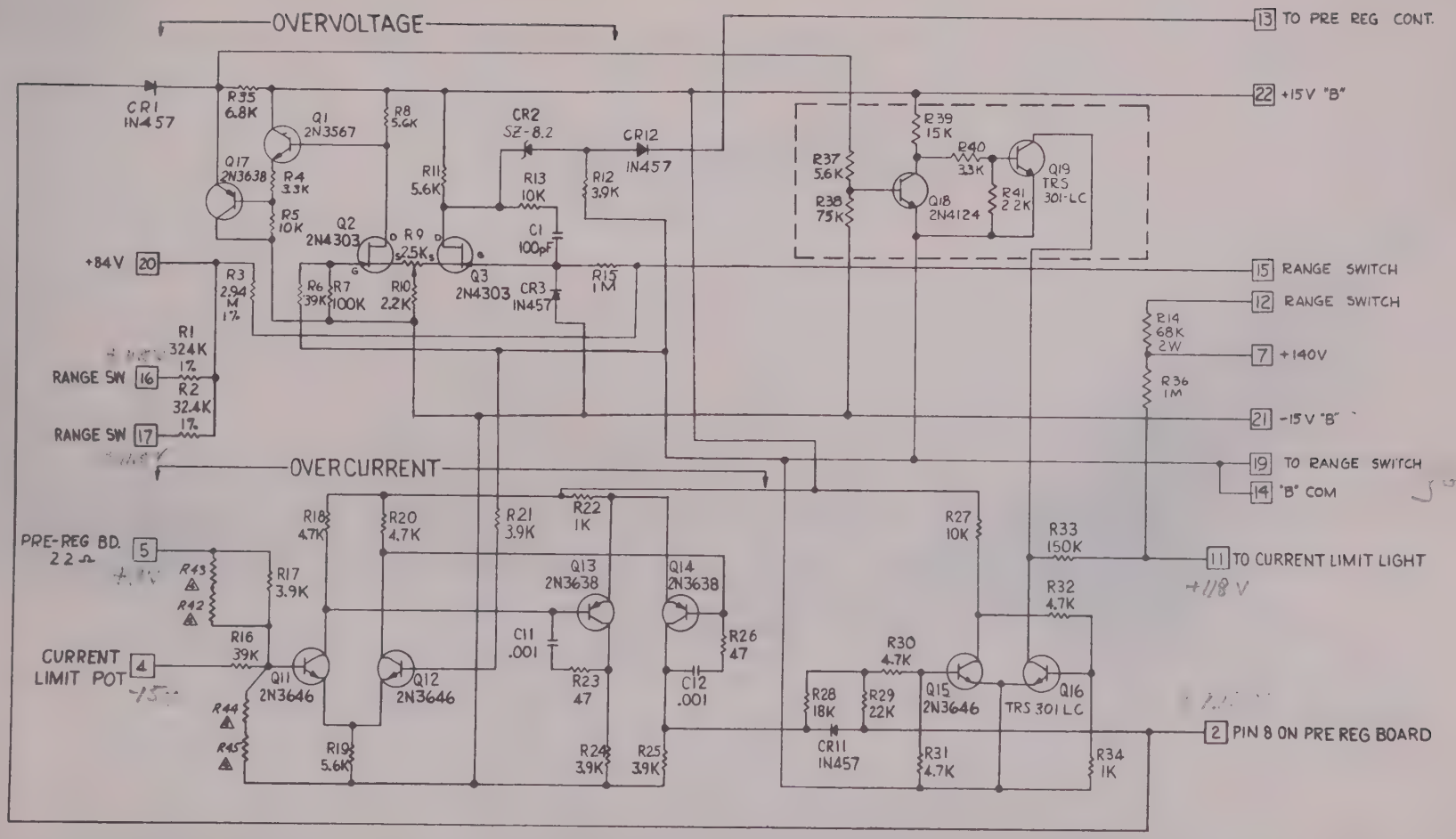
Figure 4-13. 15V Regulated Power Supply Board (A15) Schematic Diagram (Drawing No. D7822700)



5. REF. ASSEMBLY A16
4. TRANSISTORS ARE TYPE 2N3646
3. DIODES ARE TYPE 1N457
2. CAPACITOR VALUES ARE IN MICROFARADS
1. RESISTOR VALUES ARE IN OHMS, ¼ WATT

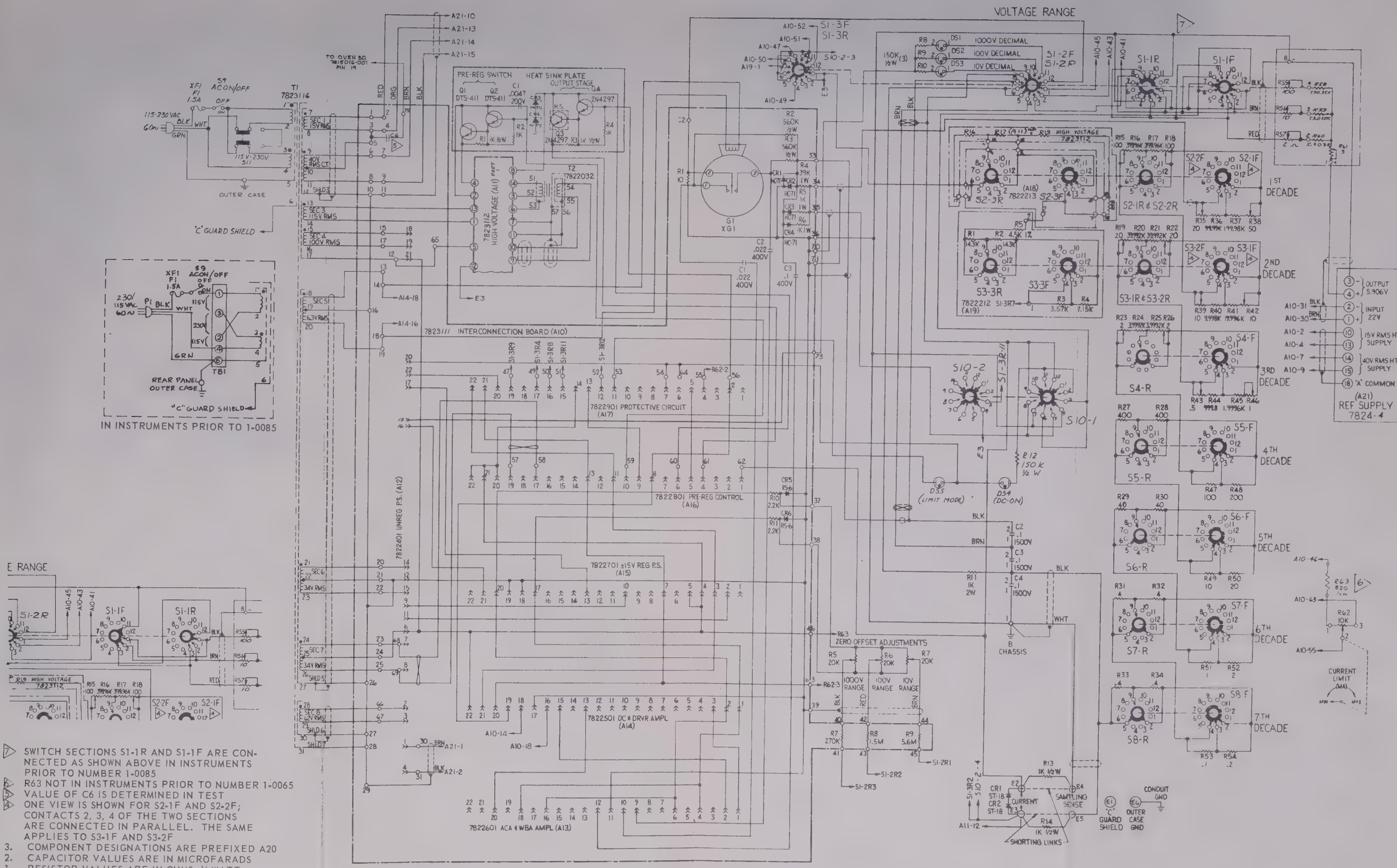
NOTES: UNLESS OTHERWISE SPECIFIED

Figure 4-14. Preregulator Control Circuit Board (A16) Schematic Diagram (Drawing No. D7822800B)



Δ VALUES OF R42 THROUGH R45 ARE SELECTED IN TEST.
3. REF. ASSEMBLY A17
2. CAPACITOR VALUES ARE IN MICROFARADS
1. RESISTOR VALUES ARE IN OHMS, ¼ WATT.
NOTES: UNLESS OTHERWISE SPECIFIED

Figure 4-15. Protective Circuit Board (A17) Schematic Diagram (Drawing No. D7822900C)



7 SWITCH SECTIONS S1-1R AND S1-1F ARE CONNECTED AS SHOWN ABOVE IN INSTRUMENTS PRIOR TO NUMBER 1-0085

6 R63 NOT IN INSTRUMENTS PRIOR TO NUMBER 1-0065

5 VALUE OF C6 IS DETERMINED IN TEST

4 ONE VIEW IS SHOWN FOR S2-1F AND S2-2F; CONTACTS 2, 3, 4 OF THE TWO SECTIONS ARE CONNECTED IN PARALLEL. THE SAME APPLIES TO S3-1F AND S3-2F

3. COMPONENT DESIGNATIONS ARE PREFIXED A20

2. CAPACITOR VALUES ARE IN MICROFARADS

1. RESISTOR VALUES ARE IN OHMS, ¼ WATT

NOTES: UNLESS INDICATED OTHERWISE

Figure 4-16. Main Schematic Diagram (Drawing No. J7823100C)

Table 4-2. Chassis Replacement Parts

CIRCUIT REF.		DESCRIPTION	COHU PART NO.
A	10	ASSEMBLY, INTERCONNECTION BOARD	7823111-001
A	11	ASSEMBLY, HIGH VOLTAGE BOARD	7823112-001
A	12	ASSEMBLY, UNREGULATED POWER SUPPLY BOARD	7822401-001
A	13	ASSEMBLY, ACA AND WBA BOARD	7822601-001
A	14	ASSEMBLY, DC AND DRIVER AMPLIFIER BOARD	7822501-001
A	15	ASSEMBLY, 15V REGULATOR BOARD	7822701-001
A	16	ASSEMBLY, PREREGULATOR CONTROL BOARD	7822801-001
A	17	ASSEMBLY, PROTECTIVE CIRCUIT BOARD	7822901-001
A	21	ASSEMBLY, REFERENCE VOLTAGE UNIT	7824-4
C	1	CAPACITOR, MYLAR, .0047UF, 400V	0610133-005
C	4	CAPACITOR, POLYSTYRENE, .1 UF, 1500 V	0610108-002
CR	1	DIODE, RECTIFIER, TYPE ST-18	3510068-004
CR	2	DIODE, RECTIFIER, TYPE ST-18	3510068-004
CR	3	DIODE, ZENER, TYPE 1N1372	3510021-007
CR	4	DIODE, ZENER, TYPE 1N1372	3510021-007
DS	1	LAMP ASSY., NEON, TYPE A1B	1710152-006
DS	2	LAMP ASSY., NEON, TYPE A1B	1710152-006
DS	3	LAMP ASSY., NEON, TYPE A1B	1710152-006
DS	4	LAMP ASSY. NEON, TYPE A1B	1710152-005
DS	5	LAMP ASSY. NEON, TYPE A1B	1710152-005
F	1	FUSE, CARTRIDGE, F02 SLO-BLO, 1.50 AMP	1710040-122
G	1	CHOPPER, CH-838-50/60	6310022-001
Q	1	TRANSISTOR, TYPE DTS-411	7210033-025
Q	2	TRANSISTOR, TYPE DTS-411	7210033-025
Q	3	TRANSISTOR, TYPE 2N4297	7210071-004
Q	4	TRANSISTOR, TYPE 2N4297	7210071-004
R	1	RESISTOR, CARBON, 1/4W, 5%, 1.0 KILOHM	4045000-102
R	2	RESISTOR, CARBON, 1/4W, 5%, 1.0 KILOHM	4045000-102
R	3	RESISTOR, CARBON, 1/4W, 5%, 1.0 KILOHM	4045000-102
R	4	RESISTOR, CARBON, 1/4W, 5%, 1.0 KILOHM	4045000-102
R	5	RESISTOR, VARIABLE, .75W, 20 KILOHM	5010105-203
R	6	RESISTOR, VARIABLE, .75W, 20 KILOHM	5010105-203
R	7	RESISTOR, VARIABLE, .75W, 20 KILOHM	5010105-203
R	8	RESISTOR, 1 WATT, 5%, 150 KILOHM	0310031-154
R	9	RESISTOR, 1 WATT, 5%, 150 KILOHM	0310031-154
R	10	RESISTOR, 1 WATT, 5%, 150 KILOHM	0310031-154
R	12	RESISTOR, 1 WATT, 5%, 150 KILOHM	0310031-154
R	13	RESISTOR, 1/2 WATT, 5%, 1 KILOHM	0310030-102
R	14	RESISTOR, 1/2 WATT, 5%, 1 KILOHM	0310030-102
R	55	RESISTOR, VARIABLE, .75W, 100 OHM	5010105-101
R	56	RESISTOR, VARIABLE, .75W, 10 OHM	5010105-100
R	57	RESISTOR, VARIABLE, .25W, 2 OHM	5010200-306
R	58	RESISTOR, W.W., N.I., .005%, 590.35 KILOHM	5210093-032
R	59	RESISTOR, W.W., N.I., .005%, 59.035 KILOHM	5210114-006
R	60	RESISTOR, W.W., N.I., .005%, 5.903 KILOHM	5210093-033
R	61	RESISTOR, VARIABLE, .75W, 3 OHM	5010200-301
S	9	SWITCH, ROTARY, SPST	6210018-007
*S	11	SWITCH, SLIDE, DPDT, LOCKING	6110066-001
T	1	TRANSFORMER, POWER	7823116-001
T	2	TRANSFORMER, 115/1200V RMS	7822032-001

* NOT IN INSTRUMENTS PRIOR TO NUMBER 1-0085

Table 4-3. Carrier and Wideband Amplifier Board Replacement Parts

CIRCUIT REF.	DESCRIPTION	COHU PART NO.
C 1	CAPACITOR, TANTALUM, 22UF, 15V	0510151-037
C 2	CAPACITOR, CERAMIC DISC, 500PF, 1KV	0401039
C 3	CAPACITOR, CERAMIC DISC, 500PF, 1KV	0401039
C 4	CAPACITOR, CERAMIC DISC, .001UF, 500V	0401046
C 5	CAPACITOR, CERAMIC DISC, .001UF, 500V	0401046
C 6	CAPACITOR, TANTALUM, 10UF, 20V	0510151-028
*C 7	CAPACITOR, TANTALUM, 22UF, 15V	0510151-037
C 8	CAPACITOR, TANTALUM, 10UF, 20V	0510151-028
C 9	CAPACITOR, TANTALUM, 22UF, 15V	0510151-037
C 10	CAPACITOR, CERAMIC DISC, 500PF, 1KV	0401039
C 11	CAPACITOR, CERAMIC DISC, 500PF, 1KV	0401039
C 12	CAPACITOR, CERAMIC DISC, .001UF, 200V	0407316-009
C 13	CAPACITOR, CERAMIC DISC, 250PF, 1KV	0401030
C 14	CAPACITOR, CERAMIC DISC, 250PF, 1KV	0401030
C 15	CAPACITOR, TANTALUM, 10UF, 20V	0510151-028
C 16	CAPACITOR, TANTALUM, 10UF, 20V	0510151-028
C 17	CAPACITOR, CERAMIC DISC, .05UF, 50V	0410009-503
*C 18	CAPACITOR, TANTALUM, 22UF, 15V	0510151-037
**C 19	CAPACITOR, ELECTROLYTIC, 100UF, 15V	0510152-031
**C 20	CAPACITOR, ELECTROLYTIC, 100UF, 15V	0510152-031
*Q 1	TRANSISTOR, TYPE 2N2608	7210075-001
♦** *Q 1	TRANSISTOR, FIELD EFFECT, TYPE 2N5104	7210075-002
*Q 2	TRANSISTOR, TYPE 2N2608	7210075-001
♦** *Q 2	TRANSISTOR, FIELD EFFECT, TYPE 2N5104	7210075-002
*Q 3	TRANSISTOR, TYPE 2N3638	7210069-001
**Q 3	TRANSISTOR, TYPE 2N3906	7210072-004
*Q 4	TRANSISTOR, TYPE 2N3638	7210069-001
**Q 4	TRANSISTOR, TYPE 2N3906	7210072-004
Q 5	TRANSISTOR, TYPE 2N4124	7210072-002
Q 6	TRANSISTOR, TYPE 2N4124	7210072-002
Q 7	TRANSISTOR, TYPE 2N697	7210035-024
Q 8	TRANSISTOR, TYPE 2N2608	7210075-001
Q 9	TRANSISTOR, TYPE 2N2608	7210075-001
Q 10	TRANSISTOR, TYPE 2N3638	7210069-001
Q 11	TRANSISTOR, TYPE 2N3638	7210069-001
Q 12	TRANSISTOR, TYPE 2N4124	7210072-002
Q 13	TRANSISTOR, TYPE 2N4124	7210072-002
Q 14	TRANSISTOR, TYPE 2N697	7210035-024
Q 15	TRANSISTOR, TYPE 2N697	7210035-024
*R 2	RESISTOR, CARBON, 1/4W, 5%, 22 MEGOHM	4045000-226
*R 3	RESISTOR, CARBON, 1/4W, 5%, 22 MEGOHM	4045000-226
R 4	RESISTOR, VARIABLE, .5W, 500 OHM	5010097-001
**R 5	RESISTOR, CARBON, 1/4W, 5%, 1.2 KILOHM	4045000-122
*R 5	RESISTOR, CARBON, 1/4W, 5%, 2.2 KILOHM	4045000-222
**R 6	RESISTOR, CARBON, 1/4W, 5%, 2.2 KILOHM	4045000-222
*R 6	RESISTOR, CARBON, 1/4W, 5%, 4.7 KILOHM	4045000-472
*R 7	RESISTOR, CARBON, 1/4W, 5%, 10 KILOHM	4045000-103
**R 7	RESISTOR, CARBON, 1/4W, 5%, 4.7 KILOHM	4045000-472
*R 8	RESISTOR, CARBON, 1/4W, 5%, 10 KILOHM	4045000-103
**R 8	RESISTOR, CARBON, 1/4W, 5%, 4.7 KILOHM	4045000-472
R 9	RESISTOR, CARBON, 1/4W, 5%, 270 OHM	4045000-271
R 10	RESISTOR, CARBON, 1/4W, 5%, 270 OHM	4045000-271

*ONLY IN INSTRUMENTS PRIOR TO NUMBER 1-0085 **NOT IN INSTRUMENTS PRIOR TO NUMBER 1-0085 ♦MATCHED PAIR

Table 4-3. Carrier and Wideband Amplifier Board Replacement Parts (Contd)

CIRCUIT REF.	DESCRIPTION	COHU PART NO.
R 11	RESISTOR, CARBON, 1/4W, 5%, 10 KILOHM	4045000-103
*R 12	RESISTOR, CARBON, 1/4W, 5%, 12 KILOHM	4045000-123
* *R 12	RESISTOR, CARBON, 1/4W, 5%, 5.6 KILOHM	4045000-562
R 13	RESISTOR, CARBON, 1/4W, 5%, 100 OHM	4045000-101
*R 14	RESISTOR, CARBON, 1/4W, 5%, 22 MEGOHM	4045000-226
R 15	RESISTOR, CARBON, 1/4W, 5%, 10 KILOHM	4045000-103
R 16	RESISTOR, CARBON, 1/4W, 5%, 100 OHM	4045000-101
R 17	RESISTOR, CARBON, 1/4W, 5%, 15 KILOHM	4045000-153
R 18	RESISTOR, CARBON, 1/4W, 5%, 15 KILOHM	4045000-153
R 19	RESISTOR, CARBON, 1/4W, 5%, 3.9 KILOHM	4045000-392
R 20	RESISTOR, CARBON, 1/4W, 5%, 22 OHM	4045000-220
R 21	RESISTOR, CARBON, 1/4W, 5%, 22 OHM	4045000-220
R 22	RESISTOR, CARBON, 1/4W, 5%, 1.2 KILOHM	4045000-122
R 23	RESISTOR, CARBON, 1/4W, 5%, 3.9 KILOHM	4045000-392
R 24	RESISTOR, 1/2 WATT, 5%, 100 OHM	0310030-101
R 25	RESISTOR, CARBON, 1/4W, 5%, 10 KILOHM	4045000-103
R 26	RESISTOR, 1/2 WATT, 5%, 100 OHM	0310030-101
R 27	RESISTOR, CARBON, 1/4W, 5%, 4.7 MEGOHM	4045000-475
R 28	RESISTOR, VARIABLE, .5W, 500 OHM	5010097-001
R 29	RESISTOR, CARBON, 1/4W, 5%, 2.2 KILOHM	4045000-222
R 30	RESISTOR, CARBON, 1/4W, 5%, 4.7 KILOHM	4045000-472
R 31	RESISTOR, CARBON, 1/4W, 5%, 10 KILOHM	4045000-103
R 32	RESISTOR, CARBON, 1/4W, 5%, 10 KILOHM	4045000-103
R 33	RESISTOR, CARBON, 1/4W, 5%, 270 OHM	4045000-271
R 34	RESISTOR, CARBON, 1/4W, 5%, 270 OHM	4045000-271
R 35	RESISTOR, CARBON, 1/4W, 5%, 10 KILOHM	4045000-103
R 36	RESISTOR, CARBON, 1/4W, 5%, 4.7 MEGOHM	4045000-475
R 37	RESISTOR, CARBON, 1/4W, 5%, 100 OHM	4045000-101
R 38	RESISTOR, CARBON, 1/4W, 5%, 12 KILOHM	4045000-123
R 39	RESISTOR, CARBON, 1/4W, 5%, 10 KILOHM	4045000-103
R 40	RESISTOR, CARBON, 1/4W, 5%, 100 OHM	4045000-101
R 41	RESISTOR, CARBON, 1/4W, 5%, 15 KILOHM	4045000-153
R 42	RESISTOR, CARBON, 1/4W, 5%, 15 KILOHM	4045000-153
R 43	RESISTOR, CARBON, 1/4W, 5%, 3.9 KILOHM	4045000-392
R 46	RESISTOR, CARBON, 1/4W, 5%, 1.2 KILOHM	4045000-122
R 47	RESISTOR, CARBON, 1/4W, 5%, 3.9 KILOHM	4045000-392
R 48	RESISTOR, CARBON, 1/4W, 5%, 27 KILOHM	4045000-273
R 49	RESISTOR, CARBON, 1/4W, 5%, 470 OHM	4045000-471
R 50	RESISTOR, CARBON, 1/4W, 5%, 2.7 KILOHM	4045000-272
R 51	RESISTOR, CARBON, 1/4W, 5%, 10 KILOHM	4045000-103
R 52	RESISTOR, 1/2 WATT, 5%, 100 OHM	0310030-101
R 53	RESISTOR, 1/2 WATT, 5%, 100 OHM	0310030-101
R 54	RESISTOR, CARBON, 1/4W, 5%, 470 KILOHM	4045000-474
R 55	RESISTOR, CARBON, 1/4W, 5%, 470 KILOHM	4045000-474
R 56	RESISTOR, CARBON, 1/4W, 5%, 10 KILOHM	4045000-103
*R 58	RESISTOR, CARBON, 1/4W, 5%, 22 MEGOHM	4045000-226
* *R 59	RESISTOR, CARBON, 1/4W, 5%, 22 MEGOHM	4045000-226
* *R 60	RESISTOR, CARBON, 1/4W, 5%, 22 MEGOHM	4045000-226
* *R 61	RESISTOR, CARBON, 1/4W, 5%, 27 KILOHM	4045000-273
* *R 62	RESISTOR, CARBON, 1/4W, 5%, 27 KILOHM	4045000-273
* *R 63	RESISTOR, CARBON, 1/4W, 5%, 27 KILOHM	4045000-273
* *R 64	RESISTOR, CARBON, 1/4W, 5%, 27 KILOHM	4045000-273

*ONLY IN INSTRUMENTS PRIOR TO NUMBER 1-0085 * *NOT IN INSTRUMENTS PRIOR TO NUMBER 1-0085

Table 4-4. DC and Driver Amplifier Board Replacement Parts

CIRCUIT REF.	DESCRIPTION	COHU PART NO.
C 1	CAPACITOR, MYLAR, .10UF, 50V	0610133-034
C 2	CAPACITOR, MYLAR, 1.00 UF, 50V	0610133-039
C 4	CAPACITOR, MYLAR, .015UF, 200V	0610133-009
C 7	CAPACITOR, MYLAR, .01UF, 200V	0610133-007
C 8	CAPACITOR, TANTALUM, 10UF, 20V	0510151-028
C 9	CAPACITOR, TANTALUM, 10UF, 20V	0510151-028
C 10	CAPACITOR, SILVER MICA, 500PF, 500V	1010006-501
C 11	CAPACITOR, MYLAR, .01UF, 200V	0610133-007
C 12	CAPACITOR, SILVER MICA, 500PF, 500V	1010006-501
C 13	CAPACITOR, MYLAR, .10UF, 50V	0610133-034
C 14	CAPACITOR, TANTALUM, 10UF, 20V	0510151-028
C 17	CAPACITOR, TANTALUM, 10UF, 20V	0510151-028
C 18	CAPACITOR, CERAMIC DISC, 56PF, 1KV	0401017
C 19	CAPACITOR, CERAMIC DISC, 56PF, 1KV	0401017
C 20	CAPACITOR, MYLAR, .001UF, 400V	0610133-001
C 21	CAPACITOR, MYLAR, .10UF, 50V	0610133-034
CR 1	DIODE, SILICON, TYPE 1N457	3510042-022
CR 2	DIODE, SILICON, TYPE 1N457	3510042-022
CR 3	DIODE, SILICON, TYPE 1N457	3510042-022
CR 4	DIODE, SILICON, TYPE 1N457	3510042-022
CR 5	DIODE, SILICON, TYPE 1N457	3510042-022
Q 1	TRANSISTOR, TYPE 2N3958	7210076-001
Q 2	TRANSISTOR, TYPE 2N3638	7210069-001
Q 3	TRANSISTOR, TYPE 2N3638	7210069-001
Q 4	TRANSISTOR, TYPE 2N4124	7210072-002
Q 5	TRANSISTOR, TYPE 2N4124	7210072-002
Q 6	TRANSISTOR, TYPE 2N4124	7210072-002
Q 7	TRANSISTOR, TYPE 2N2608	7210075-001
Q 8	TRANSISTOR, TYPE 2N2608	7210075-001
Q 9	TRANSISTOR, TYPE 2N4124	7210072-002
Q 10	TRANSISTOR, TYPE 2N4124	7210072-002
Q 11	TRANSISTOR, TYPE 2N4124	7210072-002
Q 12	TRANSISTOR, TYPE 2N4124	7210072-002
Q 13	TRANSISTOR, TYPE 2N4124	7210072-002
R 1	RESISTOR, CARBON, 1/4W, 5%, 1.0 KILOHM	4045000-102
R 2	RESISTOR, CARBON, 1/4W, 5%, 39 KILOHM	4045000-393
R 3	RESISTOR, CARBON, 1/4W, 5%, 4.7 MEGOHM	4045000-475
R 5	RESISTOR, CARBON, 1/4W, 5%, 1.0 KILOHM	4045000-102
R 6	RESISTOR, CARBON, 1/4W, 5%, 10 KILOHM	4045000-103
R 7	RESISTOR, CARBON, 1/4W, 5%, 10 KILOHM	4045000-103
R 8	RESISTOR, VARIABLE, 20%, 50 OHM	5010108-500
R 9	RESISTOR, CARBON, 1/4W, 5%, 8.2 KILOHM	4045000-822
R 10	RESISTOR, CARBON, 1/4W, 5%, 47 OHM	4045000-470
R 11	RESISTOR, CARBON, 1/4W, 5%, 10 KILOHM	4045000-103
R 12	RESISTOR, CARBON, 1/4W, 5%, 4.7 KILOHM	4045000-472
R 14	RESISTOR, CARBON, 1/4W, 5%, 100 OHM	4045000-101
R 15	RESISTOR, CARBON, 1/4W, 5%, 100 OHM	4045000-101
R 16	RESISTOR, CARBON, 1/4W, 5%, 100 OHM	4045000-101
R 17	RESISTOR, CARBON, 1/4W, 5%, 10 KILOHM	4045000-103
R 18	RESISTOR, CARBON, 1/4W, 5%, 100 OHM	4045000-101

Table 4-4. DC and Driver Amplifier Board Replacement Parts (Contd)

CIRCUIT REF.	DESCRIPTION	COHU PART NO.
R 21	RESISTOR, CARBON, 1/4W, 5%, 3.9 KILOHM	4045000-392
R 22	RESISTOR, CARBON, 1/4W, 5%, 3.9 KILOHM	4045000-392
R 23	RESISTOR, CARBON, 1/4W, 5%, 1.2 KILOHM	4045000-122
R 24	RESISTOR, CARBON, 1/4W, 5%, 100 OHM	4045000-101
R 25	RESISTOR, CARBON, 1/4W, 5%, 100 OHM	4045000-101
R 26	RESISTOR, CARBON, 1/4W, 5%, 10 KILOHM	4045000-103
R 27	RESISTOR, CARBON, 1/4W, 5%, 1.0 KILOHM	4045000-102
R 28	RESISTOR, CARBON, 1/4W, 5%, 1.5 MEGOHM	4045000-155
R 29	RESISTOR, CARBON, 1/4W, 5%, 1.0 KILOHM	4045000-102
R 30	RESISTOR, CARBON, 1/4W, 5%, 1.5 MEGOHM	4045000-155
R 31	RESISTOR, CARBON, 1/4W, 5%, 100 OHM	4045000-101
R 34	RESISTOR, CARBON, 1/4W, 5%, 680 KILOHM	4045000-684
R 35	RESISTOR, CARBON, 1/4W, 5%, 10 KILOHM	4045000-103
R 36	RESISTOR, CARBON, 1/4W, 5%, 100 OHM	4045000-101
R 37	RESISTOR, CARBON, 1/4W, 5%, 10 KILOHM	4045000-103
R 38	RESISTOR, CARBON, 1/4W, 5%, 3.3 KILOHM	4045000-332
R 39	RESISTOR, CARBON, 1/4W, 5%, 1.0 KILOHM	4045000-102
R 40	RESISTOR, CARBON, 1/4W, 5%, 100 OHM	4045000-101
R 41	RESISTOR, CARBON, 1/4W, 5%, 100 OHM	4045000-101
R 42	RESISTOR, CARBON, 1/4W, 5%, 1.0 KILOHM	4045000-102
R 43	RESISTOR, CARBON, 1/4W, 5%, 10 KILOHM	4045000-103
R 44	RESISTOR, CARBON, 1/4W, 5%, 1.0 KILOHM	4045000-102
R 45	RESISTOR, CARBON, 1/4W, 5%, 3.3 KILOHM	4045000-332
R 46	RESISTOR, CARBON, 1/4W, 5%, 1.0 KILOHM	4045000-102
R 48	RESISTOR, CARBON, 1/4W, 5%, 3.9 KILOHM	4045000-392
R 49	RESISTOR, CARBON, 1/4W, 5%, 220 OHM	4045000-221
R 50	RESISTOR, CARBON, 1/4W, 5%, 4.7 KILOHM	4045000-472
R 51	RESISTOR, CARBON, 1/4W, 5%, 3.3 MEGOHM	4045000-335
R 52	RESISTOR, CARBON, 1/4W, 5%, 330 KILOHM	4045000-334
R 53	RESISTOR, CARBON, 1/4W, 5%, 330 KILOHM	4045000-334
R 54	RESISTOR, CARBON, 1/4W, 5%, 4.7 MEGOHM	4045000-475
R 55	RESISTOR, CARBON, 1/4W, 5%, 39 KILOHM	4045000-393
R 56	RESISTOR, CARBON, 1/4W, 5%, 10 KILOHM	4045000-103
R 57	RESISTOR, CARBON, 1/4W, 5%, 10 KILOHM	4045000-103

Table 4-5. Decaded-Feedback Network Replacement Parts

CIRCUIT REF.	DESCRIPTION	COHU PART NO.
C 2	CAPACITOR, POLYSTYRENE, .1 UF, 1500 V	0610108-002
C 3	CAPACITOR, POLYSTYRENE, .1 UF, 1500 V	0610108-002
R 1	RESISTOR, W.W., N.I., 1%, 14.3 KILOHM	5210116-006
R 2	RESISTOR, W.W., N.I., 1%, 14.3 KILOHM	5210116-006
R 3	RESISTOR, W.W., N.I., 1%, 3.57 KILOHM	5210116-008
R 4	RESISTOR, W.W., N.I., 1%, 7.15 KILOHM	5210116-007
R 5	RESISTOR, METAL FILM, 1/8W, 1%, 4.5 KILOHM	5210051-010
R 11	RESISTOR, 2 WATT, 5%, 1 KILOHM	0310032-102
R 15	RESISTOR, VARIABLE, .75W, 100 OHM	5010102-101
*R 16	RESISTOR, W.W., N.I., .01%, 399.96 KILOHM	7823149-001
*R 17	RESISTOR, W.W., N.I., .01%, 399.96 KILOHM	7823149-001
R 18	RESISTOR, VARIABLE, .75W, 100 OHM	5010102-101
R 19	RESISTOR, VARIABLE, .75W, 20 OHM	5010102-200
R 20	RESISTOR, W.W., N.I., .01%, 39.992 KILOHM	5210117-003
R 21	RESISTOR, W.W., N.I., .01%, 39.992 KILOHM	5210117-003
R 22	RESISTOR, VARIABLE, .75W, 20 OHM	5010102-200
R23/R24	RESISTOR ASSEMBLY, ADJUSTABLE	7817427-018
R25/R26	RESISTOR ASSEMBLY, ADJUSTABLE	7817427-018
R 27	RESISTOR, PRECISION, .005%, 400 OHM	5210100-019
R 28	RESISTOR, PRECISION, .005%, 400 OHM	5210100-019
R 29	RESISTOR, PRECISION, .01%, 40 OHM	5210100-010
R 30	RESISTOR, PRECISION, .01%, 40 OHM	5210100-010
R 31	RESISTOR, PRECISION, .1%, 4 OHM	5210100-013
R 32	RESISTOR, PRECISION, .1%, 4 OHM	5210100-013
R 33	RESISTANCE WIRE, .4 OHM	7610036-002
R 34	RESISTANCE WIRE, .4 OHM	7610036-002
R 35	RESISTOR, VARIABLE, .75W, 20 OHM	5010102-200
*R 36	RESISTOR, W.W., N.I., .01%, 99.99 KILOHM	7823149-001
*R 37	RESISTOR, W.W., N.I., 01%, 199.98 KILOHM	7823149-001
R 38	RESISTOR, VARIABLE, .75W, 50 OHM	5010102-500
R 39	RESISTOR, VARIABLE, 10 OHMS	5010102-100
R 40	RESISTOR, W.W., N.I., 01%, 9.998 KILOHM	5210117-001
R 41	RESISTOR, W.W., N.I., .01%, 19.996 KILOHM	5210117-002
R 42	RESISTOR, VARIABLE, 10 OHMS	5010102-100
R43/R44	RESISTOR ASSEMBLY, ADJUSTABLE	7817427-017
R45/R46	RESISTOR ASSEMBLY, ADJUSTABLE	7817427-016
R 47	RESISTOR, PRECISION, .005%, 100 OHM	5210100-017
R 48	RESISTOR, PRECISION, .005%, 200 OHM	5210100-018
R 49	RESISTOR, PRECISION, .01%, 10 OHM	5210100-008
R 50	RESISTOR, PRECISION, .01%, 20 OHM	5210100-009
R 51	RESISTOR, PRECISION, .1%, 1 OHM	5210100-011
R 52	RESISTOR, PRECISION, .1%, 2 OHM	5210100-012
R 53	RESISTANCE WIRE, .1 OHM	7610036-002
R 54	RESISTANCE WIRE, .2 OHM	7610036-002
R 62	RESISTOR, VARIABLE, 10 KILOHM	5010098-002
**R 63	RESISTOR, 1/2 WATT, 5%, 820 OHM	0310030-821
S 1	SWITCH, ROTARY, 8P3P	6210159-001
◆S 1	SWITCH, ROTARY, 8P3P	6210165-001
S 2	SWITCH, ROTARY 4-4-2-1 BCD	6210160-001
S 3	SWITCH, ROTARY 4-4-2-1 BCD	6210160-001
S 4	SWITCH, ROTARY, BCD	6210136-002

*MATCHED SET **NOT IN INSTRUMENTS PRIOR TO NO. 1-0065 ◆NOT IN INSTRUMENTS PRIOR TO NO. 1-0088

Table 4-5. Decaded-Feedback Network Replacement Parts (Contd)

CIRCUIT REF.	DESCRIPTION	COHU PART NO.
S 5	SWITCH, ROTARY, BCD	6210136-002
S 6	SWITCH, ROTARY, BCD	6210136-002
S 7	SWITCH, ROTARY, BCD	6210136-002
S 8	SWITCH, ROTARY, BCD	6210136-002
S 10	SWITCH, ROTARY, 8P2T	6210162-001

Table 4-6. Unregulated Power Supply Board Replacement Parts

CIRCUIT REF.	DESCRIPTION	COHU PART NO.
C 1	CAPACITOR, ELECTROLYTIC, 4 UF, 450V	0510148-903
C 2	CAPACITOR, ELECTROLYTIC, 250UF, 50V	0510148-509
C 3	CAPACITOR, ELECTROLYTIC, 250UF, 50V	0510148-509
C 4	CAPACITOR, ELECTROLYTIC, 250UF, 50V	0510148-509
C 5	CAPACITOR, ELECTROLYTIC, 250UF, 50V	0510148-509
C 6	CAPACITOR, ELECTROLYTIC, 20 UF, 150V	0510148-606
CR 1	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 2	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 3	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 4	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 5	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 6	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 7	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 8	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 9	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 10	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 11	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 12	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 13	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 14	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 15	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 16	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 17	DIODE, ZENER, TYPE 1D100A	3510049-009
CR 18	DIODE, ZENER, TYPE VR22	3510049-016
R 1	RESISTOR, 1/2 WATT, 5%, 5.6 KILOHM	0310030-562
R 2	RESISTOR, VARIABLE, 1/8W, 10 KILOHM	5010086-001
R 3	RESISTOR, 2 WATT, 5%, 2.2 KILOHM	0310032-222

Table 4-7. Preregulator Control Board Replacement Parts

CIRCUIT REF.	DESCRIPTION	COHU PART NO.
C 1	CAPACITOR, MYLAR, .022UF, 200V	0610133-011
C 2	CAPACITOR, MYLAR, .022UF, 200V	0610133-011
CR 1	DIODE, SILICON, TYPE 1N457	3510042-022
CR 2	DIODE, SILICON, TYPE 1N457	3510042-022
CR 3	DIODE, SILICON, TYPE 1N457	3510042-022
CR 4	DIODE, SILICON, TYPE 1N457	3510042-022
CR 5	DIODE, SILICON, TYPE 1N457	3510042-022
CR 6	DIODE, SILICON, TYPE 1N457	3510042-022
CR 11	DIODE, SILICON, TYPE 1N457	3510042-022
Q 1	TRANSISTOR, TYPE 2N3646	7210068-001
Q 2	TRANSISTOR, TYPE 2N3646	7210068-001
Q 4	TRANSISTOR, TYPE 2N3646	7210068-001
Q 5	TRANSISTOR, TYPE 2N3646	7210068-001
Q 6	TRANSISTOR, TYPE 2N3646	7210068-001
Q 7	TRANSISTOR, TYPE 2N3646	7210068-001
Q 8	TRANSISTOR, FIELD EFFECT, TYPE 2N4303	7210082-002
Q 9	TRANSISTOR, TYPE 2N3646	7210068-001
R 1	RESISTOR, CARBON, 1/4W, 5%, 2.2 KILOHM	4045000-222
R 2	RESISTOR, CARBON, 1/4W, 5%, 22 KILOHM	4045000-223
R 3	RESISTOR, CARBON, 1/4W, 5%, 2.2 KILOHM	4045000-222
R 4	RESISTOR, CARBON, 1/4W, 5%, 2.2 KILOHM	4045000-222
R 5	RESISTOR, CARBON, 1/4W, 5%, 22 KILOHM	4045000-223
R 6	RESISTOR, CARBON, 1/4W, 5%, 2.2 KILOHM	4045000-222
R 7	RESISTOR, CARBON, 1/4W, 5%, 5.6 KILOHM	4045000-562
R 11	RESISTOR, CARBON, 1/4W, 5%, 8.2 KILOHM	4045000-822
R 12	RESISTOR, CARBON, 1/4W, 5%, 18 KILOHM	4045000-183
R 13	RESISTOR, CARBON, 1/4W, 5%, 2.2 KILOHM	4045000-222
R 14	RESISTOR, CARBON, 1/4W, 5%, 2.2 KILOHM	4045000-222
R 15	RESISTOR, CARBON, 1/4W, 5%, 8.2 KILOHM	4045000-822
R 16	RESISTOR, CARBON, 1/4W, 5%, 18 KILOHM	4045000-183
R 17	RESISTOR, CARBON, 1/4W, 5%, 18 KILOHM	4045000-183
R 19	RESISTOR, 1/2 WATT, 5%, 1.2 KILOHM	0310030-122
R 21	RESISTOR, CARBON, 1/4W, 5%, 1.0 KILOHM	4045000-102
R 25	RESISTOR, CARBON, 1/4W, 5%, 2.2 KILOHM	4045000-222
R 26	RESISTOR, CARBON, 1/4W, 5%, 8.2 KILOHM	4045000-822
R 27	RESISTOR, CARBON, 1/4W, 5%, 2.7 MEGOHM	4045000-275
R 28	RESISTOR, CARBON, 1/4W, 5%, 390 KILOHM	4045000-394
R 29	RESISTOR, CARBON, 1/4W, 5%, 6.8 KILOHM	4045000-682
R 41	RESISTOR, 1/2 WATT, 5%, 22 OHM	0310030-220

Table 4-8. Protective Circuit Board Replacement Parts

CIRCUIT REF.	DESCRIPTION	COHU PART NO.
C 1	CAPACITOR, CERAMIC DISC, 100PF, 1KV	0401022
C 11	CAPACITOR, CERAMIC DISC, .001UF, 500V	0401046
C 12	CAPACITOR, CERAMIC DISC, .001UF, 500V	0401046
CR 1	DIODE, SILICON, TYPE 1N457	3510042-022
CR 2	DIODE, ZENER, TYPE SZ8.2	3510049-013
CR 3	DIODE, SILICON, TYPE 1N457	3510042-022
CR 11	DIODE, SILICON, TYPE 1N457	3510042-022
CR 12	DIODE, SILICON, TYPE 1N457	3510042-022
Q 1	TRANSISTOR, TYPE 2N3567	7210069-002
Q 2	TRANSISTOR, FIELD EFFECT, TYPE 2N4303	7210082-002
Q 3	TRANSISTOR, FIELD EFFECT, TYPE 2N4303	7210082-002
Q 11	TRANSISTOR, TYPE 2N3646	7210068-001
Q 12	TRANSISTOR, TYPE 2N3646	7210068-001
Q 13	TRANSISTOR, TYPE 2N3638	7210069-001
Q 14	TRANSISTOR, TYPE 2N3638	7210069-001
Q 15	TRANSISTOR, TYPE 2N3646	7210068-001
Q 16	TRANSISTOR, TYPE TRS-301-LC	7210079-001
Q 17	TRANSISTOR, TYPE 2N3638	7210069-001
Q 18	TRANSISTOR, TYPE 2N4124	7210072-002
Q 19	TRANSISTOR, TYPE TRS-301-LC	7210079-001
R 1	RESISTOR, W.W., N.I., 1%, 324 KILOHM	5210116-005
R 2	RESISTOR, W.W., N.I., 1%, 32.4 KILOHM	5210116-004
R 3	RESISTOR, W.W., N.I., 1%, 2.94 MEGOHM	5210114-004
R 4	RESISTOR, CARBON, 1/4W, 5%, 3.3 KILOHM	4045000-332
R 5	RESISTOR, CARBON, 1/4W, 5%, 10 KILOHM	4045000-103
R 6	RESISTOR, CARBON, 1/4W, 5%, 39 KILOHM	4045000-393
R 7	RESISTOR, CARBON, 1/4W, 5%, 100 KILOHM	4045000-104
R 8	RESISTOR, CARBON, 1/4W, 5%, 5.6 KILOHM	4045000-562
R 9	RESISTOR, VARIABLE, 1/8W, 2.5 KILOHM	5010086-005
R 10	RESISTOR, CARBON, 1/4W, 5%, 2.2 KILOHM	4045000-222
R 11	RESISTOR, CARBON, 1/4W, 5%, 5.6 KILOHM	4045000-562
R 12	RESISTOR, CARBON, 1/4W, 5%, 3.9 KILOHM	4045000-392
R 13	RESISTOR, CARBON, 1/4W, 5%, 10 KILOHM	4045000-103
R 14	RESISTOR, 2 WATT, 5%, 68 KILOHM	0310032-683
R 15	RESISTOR, CARBON, 1/4W, 5%, 1.0 MEGOHM	4045000-105
R 16	RESISTOR, CARBON, 1/4W, 5%, 39 KILOHM	4045000-393
R 17	RESISTOR, CARBON, 1/4W, 5%, 3.9 KILOHM	4045000-392
R 18	RESISTOR, CARBON, 1/4W, 5%, 4.7 KILOHM	4045000-472
R 19	RESISTOR, CARBON, 1/4W, 5%, 5.6 KILOHM	4045000-562
R 20	RESISTOR, CARBON, 1/4W, 5%, 4.7 KILOHM	4045000-472
R 21	RESISTOR, CARBON, 1/4W, 5%, 3.9 KILOHM	4045000-392
R 22	RESISTOR, CARBON, 1/4W, 5%, 1.0 KILOHM	4045000-102
R 23	RESISTOR, CARBON, 1/4W, 5%, 47 OHM	4045000-470
R 24	RESISTOR, CARBON, 1/4W, 5%, 3.9 KILOHM	4045000-392
R 25	RESISTOR, CARBON, 1/4W, 5%, 3.9 KILOHM	4045000-392
R 26	RESISTOR, CARBON, 1/4W, 5%, 47 OHM	4045000-470
R 27	RESISTOR, CARBON, 1/4W, 5%, 10 KILOHM	4045000-103
R 28	RESISTOR, CARBON, 1/4W, 5%, 18 KILOHM	4045000-183
R 29	RESISTOR, CARBON, 1/4W, 5%, 22 KILOHM	4045000-223
R 30	RESISTOR, CARBON, 1/4W, 5%, 4.7 KILOHM	4045000-472

Table 4-8. Protective Circuit Board Replacement Parts (Contd)

CIRCUIT REF.	DESCRIPTION	COHU PART NO.
R 31	RESISTOR, CARBON, 1/4W, 5%, 4.7 KILOHM	4045000-472
R 32	RESISTOR, CARBON, 1/4W, 5%, 4.7 KILOHM	4045000-472
R 33	RESISTOR, CARBON, 1/4W, 5%, 150 KILOHM	4045000-154
R 34	RESISTOR, CARBON, 1/4W, 5%, 1.0 KILOHM	4045000-102
R 35	RESISTOR, CARBON, 1/4W, 5%, 6.8 KILOHM	4045000-682
R 36	RESISTOR, CARBON, 1/4W, 5%, 1.0 MEGOHM	4045000-105
R 37	RESISTOR, CARBON, 1/4W, 5%, 5.6 KILOHM	4045000-562
R 38	RESISTOR, CARBON, 1/4W, 5%, 75 KILOHM	4045000-753
R 39	RESISTOR, CARBON, 1/4W, 5%, 15 KILOHM	4045000-153
R 40	RESISTOR, CARBON, 1/4W, 5%, 3.3 KILOHM	4045000-332
R 41	RESISTOR, CARBON, 1/4W, 5%, 2.2 KILOHM	4045000-222
*** R 42	RESISTOR, CARBON, 1/4W, 5%, ***OHM	4045000-***
*** R 43	RESISTOR, CARBON, 1/4W, 5%, ***OHM	4045000-***
*** R 44	RESISTOR, CARBON, 1/4W, 5%, ***OHM	4045000-***
*** R 45	RESISTOR, CARBON, 1/4W, 5%, ***OHM	4045000-***

*** SELECTED IN TEST

Table 4-9. High Voltage Board Replacement Parts

CIRCUIT REF.	DESCRIPTION	COHU PART NO.
C 1	CAPACITOR, ELECTROLYTIC, 20 UF, 450V	0510122-002
C 2	CAPACITOR, ELECTROLYTIC, 20 UF, 450V	0510122-002
C 3	CAPACITOR, ELECTROLYTIC, 20 UF, 450V	0510122-002
C 4	CAPACITOR, ELECTROLYTIC, 20 UF, 450V	0510122-002
C 5	CAPACITOR, LINE BY-PASS, .02UF, 1.4KV	0410013-001
CR 1	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 2	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 3	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 4	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 5	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 6	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 7	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 8	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 9	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 10	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 11	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 12	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 13	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 14	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 15	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 16	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
R 1	RESISTOR, 1 WATT, 5%, 270 KILOHM	0310031-274
R 2	RESISTOR, 1 WATT, 5%, 270 KILOHM	0310031-274
R 3	RESISTOR, 1 WATT, 5%, 270 KILOHM	0310031-274
R 4	RESISTOR, 1 WATT, 5%, 270 KILOHM	0310031-274
R 5	RESISTOR, W.W., 5W, 500 OHM	5110010-028
R 16	RESISTOR ASSEMBLY, PART OF, 1%, 143 KILOHM	7823164-001
R 17	RESISTOR ASSEMBLY, PART OF, 1%, 143 KILOHM	7823164-001
R 18	RESISTOR ASSEMBLY, PART OF, 1%, 35.7 KILOHM	7823164-002
R 19	RESISTOR ASSEMBLY, PART OF, 1%, 71.5 KILOHM	7823164-002

Table 4-10. 15V Regulated Power Supply Board Replacement Parts

CIRCUIT REF.	DESCRIPTION	COHU PART NO.
C 1	CAPACITOR, ELECTROLYTIC, 10UF, 50V	0510150-005
C 2	CAPACITOR, ELECTROLYTIC, 10UF, 50V	0510150-005
C 3	CAPACITOR, CERAMIC, .02UF, 50V	0410009-203
C 4	CAPACITOR, CERAMIC, .02UF, 50V	0410009-203
C 21	CAPACITOR, ELECTROLYTIC, 10UF, 50V	0510150-005
C 22	CAPACITOR, ELECTROLYTIC, 10UF, 50V	0510150-005
C 23	CAPACITOR, CERAMIC, .02UF, 50V	0410009-203
C 24	CAPACITOR, CERAMIC, .02UF, 50V	0410009-203
Q 1	TRANSISTOR, TYPE 2N4124	7210072-002
Q 2	TRANSISTOR, TYPE 2N3646	7210068-001
Q 3	TRANSISTOR, TYPE 40361	7210035-042
Q 4	TRANSISTOR, TYPE 2N3646	7210068-001
Q 5	TRANSISTOR, TYPE 2N3638	7210069-001
Q 6	TRANSISTOR, TYPE 2N4250	7210068-003
Q 7	TRANSISTOR, TYPE 2N3638	7210069-001
Q 8	TRANSISTOR, TYPE 40362	7210035-043
Q 9	TRANSISTOR, TYPE 2N3638	7210069-001
Q 10	TRANSISTOR, TYPE 2N3646	7210068-001
Q 11	TRANSISTOR, TYPE 2N3646	7210068-001
Q 12	TRANSISTOR, TYPE 2N3646	7210068-001
Q 21	TRANSISTOR, TYPE 2N4124	7210072-002
Q 22	TRANSISTOR, TYPE 2N3646	7210068-001
Q 23	TRANSISTOR, TYPE 40361	7210035-042
Q 24	TRANSISTOR, TYPE 2N3646	7210068-001
Q 25	TRANSISTOR, TYPE 2N3638	7210069-001
Q 26	TRANSISTOR, TYPE 2N4250	7210068-003
Q 27	TRANSISTOR, TYPE 2N3638	7210069-001
Q 28	TRANSISTOR, TYPE 40362	7210035-043
Q 29	TRANSISTOR, TYPE 2N3638	7210069-001
Q 30	TRANSISTOR, TYPE 2N3646	7210068-001
Q 31	TRANSISTOR, TYPE 2N3646	7210068-001
Q 32	TRANSISTOR, TYPE 2N3646	7210068-001
R 1	RESISTOR, CARBON, 1/4W, 5%, 6.8 KILOHM	4045000-682
R 2	RESISTOR, CARBON, 1/4W, 5%, 390 OHM	4045000-391
R 3	RESISTOR, CARBON, 1/4W, 5%, 22 KILOHM	4045000-223
R 4	RESISTOR, CARBON, 1/4W, 5%, 1.5 KILOHM	4045000-152
R 5	RESISTOR, 1/2 WATT, 5%, 10 OHM	0310030-100
R 6	RESISTOR, CARBON, 1/4W, 5%, 1.0 KILOHM	4045000-102
R 7	RESISTOR, CARBON, 1/4W, 5%, 3.9 KILOHM	4045000-392
R 8	RESISTOR, VARIABLE, 1/8W, 1 KILOHM	5010086-003
R 9	RESISTOR, CARBON, 1/4W, 5%, 4.7 KILOHM	4045000-472
R 10	RESISTOR, CARBON, 1/4W, 5%, 390 OHM	4045000-391
R 11	RESISTOR, CARBON, 1/4W, 5%, 6.8 KILOHM	4045000-682
R 12	RESISTOR, CARBON, 1/4W, 5%, 22 KILOHM	4045000-223
R 13	RESISTOR, CARBON, 1/4W, 5%, 1.5 KILOHM	4045000-152
R 14	RESISTOR, 1/2 WATT, 5%, 10 OHM	0310030-100
R 15	RESISTOR, CARBON, 1/4W, 5%, 1.0 KILOHM	4045000-102
R 16	RESISTOR, CARBON, 1/4W, 5%, 3.9 KILOHM	4045000-392
R 17	RESISTOR, VARIABLE, 1/8W, 1 KILOHM	5010086-003
R 18	RESISTOR, CARBON, 1/4W, 5%, 4.7 KILOHM	4045000-472

Table 4-10. 15V Regulated Power Supply Board Replacement Parts (Contd)

CIRCUIT REF.	DESCRIPTION	COHU PART NO.
R 21	RESISTOR, CARBON, 1/4W, 5%, 6.8 KILOHM	4045000-682
R 22	RESISTOR, CARBON, 1/4W, 5%, 390 OHM	4045000-391
R 23	RESISTOR, CARBON, 1/4W, 5%, 22 KILOHM	4045000-223
R 24	RESISTOR, CARBON, 1/4W, 5%, 1.5 KILOHM	4045000-152
R 25	RESISTOR, 1/2 WATT, 5%, 3.9 OHM	0310030-039
R 26	RESISTOR, CARBON, 1/4W, 5%, 1.0 KILOHM	4045000-102
R 27	RESISTOR, CARBON, 1/4W, 5%, 3.9 KILOHM	4045000-392
R 28	RESISTOR, VARIABLE, 1/8W, 1 KILOHM	5010086-003
R 29	RESISTOR, CARBON, 1/4W, 5%, 4.7 KILOHM	4045000-472
R 30	RESISTOR, CARBON, 1/4W, 5%, 390 OHM	4045000-391
R 31	RESISTOR, CARBON, 1/4W, 5%, 6.8 KILOHM	4045000-682
R 32	RESISTOR, CARBON, 1/4W, 5%, 22 KILOHM	4045000-223
R 33	RESISTOR, CARBON, 1/4W, 5%, 1.5 KILOHM	4045000-152
R 34	RESISTOR, 1/2 WATT, 5%, 3.9 OHM	0310030-039
R 35	RESISTOR, CARBON, 1/4W, 5%, 1.0 KILOHM	4045000-102
R 36	RESISTOR, CARBON, 1/4W, 5%, 3.9 KILOHM	4045000-392
R 37	RESISTOR, VARIABLE, 1/8W, 1 KILOHM	5010086-003
R 38	RESISTOR, CARBON, 1/4W, 5%, 4.7 KILOHM	4045000-472

Table 4-11. Interconnection Board Replacement Parts

CIRCUIT REF.	DESCRIPTION	COHU PART NO.
C 1	CAPACITOR, POLYSTYRENE, .022UF, 400V	0610067-223
C 2	CAPACITOR, POLYSTYRENE, .022UF, 400V	0610067-223
C 3	CAPACITOR, POLYSTYRENE, .1UF, 400V	0610067-104
C 6	CAPACITOR, POLYSTYRENE, .12UF, 100V	0610138-124
CR 1	DIODE, SILICON, TYPE HC71	3510053-005
CR 2	DIODE, SILICON, TYPE HC71	3510053-005
CR 3	DIODE, SILICON, TYPE HC71	3510053-005
CR 4	DIODE, SILICON, TYPE HC71	3510053-005
CR 5	DIODE, ZENER, TYPE RS-6	3510022-004
CR 6	DIODE, ZENER, TYPE RS-6	3510022-004
R 1	RESISTOR, CARBON, 1/4W, 5%, 10 OHM	4045000-100
R 2	RESISTOR, 1/2 WATT, 5%, 560 KILOHM	0310030-564
R 3	RESISTOR, 1/2 WATT, 5%, 560 KILOHM	0310030-564
R 4	RESISTOR, 1 WATT, 5%, 39 KILOHM	0310031-393
R 5	RESISTOR, 1 WATT, 5%, 1 KILOHM	0310031-102
R 6	RESISTOR, 1 WATT, 5%, 1 KILOHM	0310031-102
R 7	RESISTOR, CARBON, 1/4W, 5%, 270 KILOHM	4045000-274
R 8	RESISTOR, CARBON, 1/4W, 5%, 1.5 MEGOHM	4045000-155
R 9	RESISTOR, CARBON, 1/4W, 5%, 5.6 MEGOHM	4045000-565
R 10	RESISTOR, CARBON, 1/4W, 5%, 2.2 KILOHM	4045000-222
R 11	RESISTOR, CARBON, 1/4W, 5%, 2.2 KILOHM	4045000-222

WARRANTY

Cohu Electronics, Inc., warrants equipment manufactured to be free from defects of material and workmanship. Any part or parts will be repaired or replaced when proven by COHU examination to have been defective within one year (90 days for batteries, fuses, transistors and tubes) from date of shipment to the original purchaser. All warranty repairs will be performed at the factory or as otherwise authorized by COHU in writing. Transportation charges shall be prepaid by purchaser.

This warranty does not extend to COHU equipment subjected to misuse, accident, neglect or improper application, nor repaired or altered by other than COHU or those authorized by COHU in writing.

This warranty is in lieu of all other warranties express or implied. COHU shall not be liable for collateral or consequential damages.

For customer convenience, service departments are maintained throughout the United States by COHU Field Engineering Representatives.

COHU
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SAN DIEGO DIVISION

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